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Possible Limiting Factors of the Ringneck Pheasant Population in Southern Rhode Island

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POSSIBLE LIMITING FACTORS OF THE RINGNECK PHEASANT POPULATION IN SOUTHERN RHODE ISLAND

BY

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ABSTRACT

The purpose of this project was to investigate the possible limiting factors of the ringneck pheasant population in southern Rhode Island. Two factors, food and weather, were considered in detail. The research area chosen was a typical non-urban area of southern Rhode Island, the Great Swamp Wildlife Reservation, in the township of South Kingstown. This reservation has been under the supervision of the State Division of Fish and Game for the past six years. Census and life history studies were abandoned after a year of weekly observations because of failure to collect significant amounts of data. An analysis by occurrence and volume was made of foods found in 64 crops collected from wild and stocked pheasants throughout the State during November, 1955. Wild birds ate a greater volume and a larger number of species of wild foods than stocked birds, although cultivated grains made up almost two-thirds of the food volume. In a fall and winter plant survey, only eight food species, making up less than one percent of the total volume of foods eaten, occurred as dominants in uncultivated areas. It was concluded that together with the low grain acreages in Rhode Island, the abundance of native plant foods was too low to sustain a large pheasant population through the winter. Preliminary examinations were made of the sands and gravels in six 100-gram soil samples taken in or near

the Reservation; the calcium-bearing minerals found were chlorite and a black carboniferous schist, both in amounts less than one-tenth of one percent. The results indicated that it is possible that a lack of calcium in the soil may be one of the limiting factors of the Rhode Island pheasant populations. A Bendix aerograph, recording temperature, relative humidity, and barometric pressure was set out in the Reservation in July, 1954, three inches above the ground, enabling a comparison between three-inch and standard five-foot temperatures. Temperatures near the ground were colder at night, warmer during the day, conditions that tend to affect chicks adversely after sundown but favorably during the day. When the weather for the spring and summer in Rhode Island was compared with that in regions of the United States with high pheasant populations, the important differences noted were that Rhode Island has less sunshine, more cloudy days, fewer clear days, and longer lasting storms. Because young pheasant chicks are exceedingly vulnerable to wetting and chilling, it would seem that the extensive cloudy weather found in Rhode Island following rain might increase chick mortality significantly.

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I. INTRODUCTION

This investigation is an attempt to find out why the ringneck pheasant, Phasianus colchicus Gmelin, does not breed in larger numbers in southern Rhode Island. The solution to this problem is believed to be found in a study of the ecology of the bird and in the comparison of highly producing habitats with low producing areas.

The ringneck pheasant has been the focus of much interest as a popular game animal in the United States ever since the first attempt (incidentally unsuccessful) to introduce it into New Jersey in 1790 (Leopold, 1931). The original range of the bird extends from the Caucasus Mountains in south-eastern Europe to Asia and Japan. From there it was brought to Europe and England where it became established and from the last century and a half, has been introduced extensively into the United States and breeds with at least a slight degree of success over the temperate regions, wherever croplands and farming are found.

There is wide variation in the size of populations found in different areas. In the corn belt states, where pheasant populations are highest, one cock bird per acre, or from 200 to 400 per square mile is considered a good harvest, while in peak population years on limited areas such as Peelee Island, Ontario, populations may rise as high as three or four birds per acre (Allen, 1953). Rhode Island has a land area of 1058 square miles; using the table of hunter kill records (p. 7) compiled from records of the Rhode Island Division of Fish and Game and Rhode Island Phamphlet No. 4 (Wright, 1953), the calculated average is 5.1 wild birds per square mile during 12 years from the period of 1940 to 1955. Allowing for considerable error in hunting reports and for the fact that not all wild birds are harvested, this is a relatively low figure, and Rhode Island is apparently not a good pheasant producing state. In a personal conversation with Mr. Albert Zurlinden of the Rhode Island Division of Fish and Game, Mr. Zurlinden stated that the specific reasons for the failure to produce an abundant wild pheasant population remain unknown, in spite of numerous attempts to study the question not only in New England but throughout the country.

According to Trippensee (Trippensee, 1948), the bird that is hunted today is not a single well defined species but the result of the interbreeding of two taxons and some of their varieties, <u>Phasianus</u> <u>colchicus</u> <u>torquatus</u> (Chinese ringneck pheasant), <u>P</u>. <u>colchicus</u> <u>mongolicus</u> (Mongolian ringneck pheasant), <u>P</u>. <u>colchicus</u> <u>colchicus</u> (English blackneck pheasant), and <u>P</u>. <u>versicolor</u> (Japanese pheasant). The Chinese and Mongolian pheasants have a white ring around the neck and were the ones most frequently introduced and bred in this country. Variation in coloring and marking can readily be observed in different localities, and in fact, Allen

Table 1. Estimates of wild and stocked ringneck pheasants killed in Rhode Island during the hunting seasons from 1940 through 1952* and for 1955.**

Year	cocks stocked	total returned	wild birds returned	average wild birds per square mile
1940	1,150	8,057	7,890	7.5
1941	1,390	10,854	10,723	10.1
1942	970	4,415	4,348	4.1
1945	1,300	4,415	4,359	4.1
1946	1,160	3,701	3,630	3.4
1947	1,590	7,649	7,376	7.0
1948	2,010	6,291	4,184	4.0
1949	1,845	5,631	3,815	3.6
1950	1,960	5,770	3,560	3.6
1951	1,783	4,717	2,934	2.8
1952	1,800	6,849	5,049	4.8
1955	2,938	------	7,337	6.9
Average	-----	------	5,433.8	5.1

* 1943 and 1944 omitted because of incomplete records for those years.

** Data for the years of 1940 through 1951 were taken from Wright, 1953. Data for 1952 and 1955 come from the records of the Rhode Island Division of Fish and Game.

(Allen, 1953) observes that there are now 42 distinctly marked forms.

The life history of the pheasant has been studied in detail by a number of competent workers in the wildlife field (Beebe, 1936, Leopold, 1931, Edminister, 1954). Briefly, it is as follows:

In late February or early March the cocks become active, each one selecting a crowing area, which may vary in size from a few to 70 or more acres, the total amount of territory taken depending upon cock density. The territory usually includes much brushy cover in which courting and mating take place, and in addition, a nearby feeding area. Each cock patrols his tract shortly before and after sunrise and again near sunset, crowing, fighting off other cocks, and displaying himself to any nearby hens. These activities may continue through June, but after mating the display vigor declines. Pheasants are usually polygamous, and from late March through April from two to eight hens mate with the cock and start to make nests in his territory. A clutch of eight to thirteen or more eggs is layed in a shallow depression, preferably in an area of dense grassy cover such as hayfields, ditches, swamp borders, or less occasionally, brush and grainfields. In the case of nest failure because of flooding, predators, etc., then hen usually makes a new nest, and may, with repeated failure, continue to do so through July. If the eggs hatch and the chicks subsequently die, however, a new nest is not made. The hen incubates the eggs for 23 to 25 days, resting at dawn and in the late afternoon. The cock takes no further care of the hen or the eggs except to patrol the area. The chicks begin to hatch in the middle of May, building up to a hatching peak in the second or third week of June, and by the end of July, practically all clutches have hatched. The chicks leave the nest immediately and are brooded by the hen. Before the end of the second week, flight feathers develop and the chick is capable of short flights. By the end of the first month, the inner primary feathers drop and new ones grow in, and in six weeks the chicks are fully feathered. The food of young pheasants consists chiefly of insects and tender vegetation. As the chicks mature, berries and especially grains are taken in higher proportion; wild seeds and grains compose most of their diet as adult birds. By the end of the second month the chicks start to take on adult coloring and in late August the broods begin to mix. As the weather turns colder all the birds retire to dense brushy cover, coming out only to feed during the late morning and again in mid-afternoon; during the short winter days they appear in the middle of the day. At this time the sexes often segregate into small flocks, feeding and roosting separately until the return of spring.

In only a few local areas in this state the ringneck reproduces in numbers large enough to provide even moderate hunting, and for this reason Rhode Island has practiced stocking in the last few years purely on a "put and take" basis in order to satisfy the hunting demand. At the same time, the

Rhode Island Division of Fish and Game has been carrying out a habitat improvement program in certain designated areas with the object of building and sustaining a wild breeding population. The Great Swamp Wildlife Reservation is one such area. To date, the program has been unsuccessful.

The Great Swamp Reservation is representative of the habitat for much of this area of southern New England, and was chosen as the study area for this investigation both because of its nearness and accessibility, and because of the program mentioned above that the state has practiced since 1951. The reservation is located in southern Rhode Island in the township of South Kingstown, and covers an area of approximately 2,600 acres. A large part of the reservation is marshland which almost completely surrounds a narrow tongue of somewhat elevated land called the Great Neck. This raised portion is the place where the State habitat project is being put into effect (Figure 1, opposite page 11).

The history of the Great Neck is one typical of Rhode Island and much of southern New England. It is glaciated land, and before settlement was probably covered with an oak-chestnut forest climax association. The forest was largely destroyed, and three farms were established, but in the early part of this century these were abandoned, and the area was purchased in 1951 by the State. The land is now in all succession stages of reversion to the original vegetational types, from open weedy fields to complete reforestation.

For the past five years the State has been planting increasing acreages in hay and grains as a part of its habitat program. A small number of pine trees has been set out, but otherwise no attempts have been made to reclaim most of the abandoned areas. Some of the grain is harvested for use in other state projects and a small amount of lumber is logged out annually. Before planting, the fields are bulldozed in order to remove the rank woody brush, which is then piled in ridges between the planted areas. These ridges have grown up vigorously and provide excellent ecotomes for the use of many wildlife species. There is a network of farm roads throughout the Great Neck, an area that is also crossed by a power line as well as the New Haven Railroad. Part of the southern boundry of the reservation, (and also the Great Neck) is a lake of 650 acres called Worden Pond. Three small inlets and one outlet flow through the marsh which more or less surrounds the lake.

Shelford's "Law of Tolerance" states that "absence or failure of an organism can be controlled by the qualitative or quantitative deficiency or excess with respect to any one of several factors which may approach the limit of tolerance for that organism" (Odum, 1953). This concept is highly significant in a problem of this kind, and infers the best procedures to be followed. In order to reach a solution, the essential factors for survival of all stages in the life history of the bird in a satisfactory habitat must be found, together with pinpointing which of these factors are near the tolerance limits under the given situation or habitat, in this case southern Rhode Island.

Although a field study does not lend itself easily to the rigorous control possible in a laboratory, much can be learned by the processes of careful observation and cautious comparison of data. As indicated above, in a competent study no part of the animal's ecology can be omitted. Such a study should include not only the habitat, life cycle, food requirements, predator and competitor relationships, but also less obvious considerations as the psychology of the animal, its endocrine activity, digestion, physiology and instinctive behavior and preferences. All of these facets cannot be covered within the time limits of an investigation of as short duration as this one. By studying the literature it has been possible to evaluate to some extent the importance of a number of ecological factors presumably prominent in the survival of the pheasant, and thus omit those that seem at present to be less important or that are already well explored. It appears that the most probable limiting factors in Rhode Island might be climate and/or food; therefore, most of the work of this investigation has been concentrated accordingly.

Several ideas must be kept in mind when working with as physiologically complex an organism as the ringneck pheasant. It is difficult to isolate the effect of any one environmental factor; each factor interacts with many others. Even if factor limitation were possible, in the analysis of a field problem it would not be desirable. The object of such an investigation is an understanding of interacting factors in order to derive a practical solution for the problem. Further, each animal species possesses in its heredity the ability to adjust or react to many more situations than those under which it is originally found. The ability apparently varies according to each factor affecting the species. The pheasant seems to possess this ability in large quantity, if solely for the reason that it flourishes under many environments different from its homeland: Hawaii, Australia, Europe and England, as well as the United States (Leopold, 1931).

The cumulative detrimental effect of several factors that fluctuate about the tolerance limits may be almost as great as one single factor remaining steadily above or below the limits. The population subject to such conditions may be weakened or reduced to the extent where formerly unimportant factors become significant in terms of population numbers. For instance, a population suffering from starvation may be more susceptible to predation than it normally would be. This is probably the case in the border areas of the range of a species.

Because extensive comparison of previous work is used in the discussion of this paper, it was felt that a review of the literature at this time would be merely repetitious. An attempt to review all of the literature on the ecology of the pheasant was thought to be unnecessary because several good general summaries are now available (Nestler, 1939, Trippensee, 1948, Allen, 1953, Edminister, 1954).

II. THE INVESTIGATION

A. Methods of Procedure

1. Stocking of pheasants

At the initiation of this project in the fall of 1954, it was thought by game officials at the Great Swamp Refuge that there were no hen pheasants in the area. Though a few hens had been stocked in previous years, they had not been banded and no records had been kept of the numbers released or of the time and site of release. Because of their extensive pheasant program and consequent interest in this project the State Division of Fish and Game offered to procure 30 additional hens for release in the Great Swamp. Because cock pheasants had been stocked for the hunting season and returns were never high, it was assumed that there would be some birds remaining in the area for breeding stock, and that it would not be necessary to release more.

It was decided to stock the hens in three lots of ten each, one in the fall of 1954, following the hunting season, one lot in March, 1955 and one lot in December, 1955. The fall and following spring stockings were for the purpose of determining the effect of winter conditions on survival and breeding activity. It was felt that the March stocking, while escaping severe or prolonged winter conditions, would still be early enough before the actual breeding season to acclimatize the birds, and provide for a valid comparison. The first lot of hens did not arrive until January, 1955, and could not be released until the first week of February. Winter conditions continued in February of that year so that this delay probably would not upset the comparisons with the March stocking to a great degree. The State habitat work at the swamp has been done in three areas (Figure 1). Previous observations by the wildlife technicians and game wardens showed that one area (area I) usually had no birds in it, another area (area II) a few birds, and a third area (area III) seemed to be their favorite site. On the basis of these observations, four hens were released in area II, six in area III, and none in area I. The violent release method was used at all times (Roby, 1951). This method involves releasing merely by throwing the bird into the air. On the advice of the game warden assisting in the releasing, the pheasants stocked in March were dived equally, five being released in area II and five in area III. In May the state was given ten hens, and these were released at that time under this project, again five in area II and five in area III. By the fall of 1955, it had become apparent for reasons later discussed that this part of the project should be abandoned, and the December lot was not stocked.

2. Banding of pheasants

Since the birds released would not be recaptured, and because the shooting of hens is illegal, there would be no opportunity provided to gather information on the birds other than by field observation. For this reason it was thought desirable to mark the birds in order that they would be readily recognizable at a distance. The customary leg bands, even if colored, are very small and difficult to see quickly. The various methods of painting or dying the feathers were considered and discarded because it had been noted that the colors remain for only a limited time, and the mark would in any case be lost at the time of moulting (Jones, 1950, Kozicky and Weston, 1952). Mr. John Cronan of the State Division of Fish and Game suggested the possibility of neck bands. A band on the neck would probably be large enough and in a sufficiently prominent position to be easily seen. Balham and Elder (Balham and Elder, 1953) have described the use of plexiglass for leg bands on waterfowl. It was decided to try this material for neck bands. Plexiglass is a thermoplastic acrylic resin made in a wide variety of brilliant colors, both clear and opaque, is highly resistant to abrasion and fading, can be bought in sheets of the desired thickness, and is relatively inexpensive. It can be sawed with an ordinary fine-toothed band saw and marked either by a stamping process or special inks.

Preliminary measurements of neck circumference and head height were taken from hen pheasants at the Peace Dale Shooting Preserve by courtesy of Mr. Edward Frisella. From the rough measurements taken, it was decided that a band five inches in length would be large enough to encircle the bird's neck comfortably and yet not slip over the head. The first bands tried were cut five inches long by three-eighths inches wide from plastic one-eighth inch thick, in three opaque colors, bright red (no. 2039), yellow (no. 2037), and blue (no. 2050). These bands were ordered from the Hub Stamping and Engraving Company in Boston, Massachusetts. It was thought that these three colors would be observed easily both against the plumage of the bird and the foliage background at all times of the year. These bands were placed upon the first lot of birds in various color combinations in order to identify each bird individually.

The technique of banding follows that described by Balham and Elder (Balham and Elder, 1953): (See Figure 2 and Figure 3). The bands were heated in a small dutch oven over a portable stove of the primus or sterno type. When soft enough to be formed easily the band was quickly wrapped around the neck of the pheasant being held by a second person, and the ends brought together. It was found that shaping with the fingers was not very satisfactory. A pair of shaping tongs was constructed for the last banding experiment in a manner similar to those used by Balham and Elder in which an inch section of one-and-one-quarter-inch copper pipe was sawed lengthwise into two halves and these halves soldered onto the tips of ordinary nine-inch crucible tongs. These were very satisfactory, and with a little practice the operator was able to produce good closure of the band ends and an undistorted circular shape.

The five by three-eighths inch bands were placed also

Immersing pheasant's head with band in water

Removing plastic band from stove

Forming soft band with tongs

A hen pheasant

Figure 2.

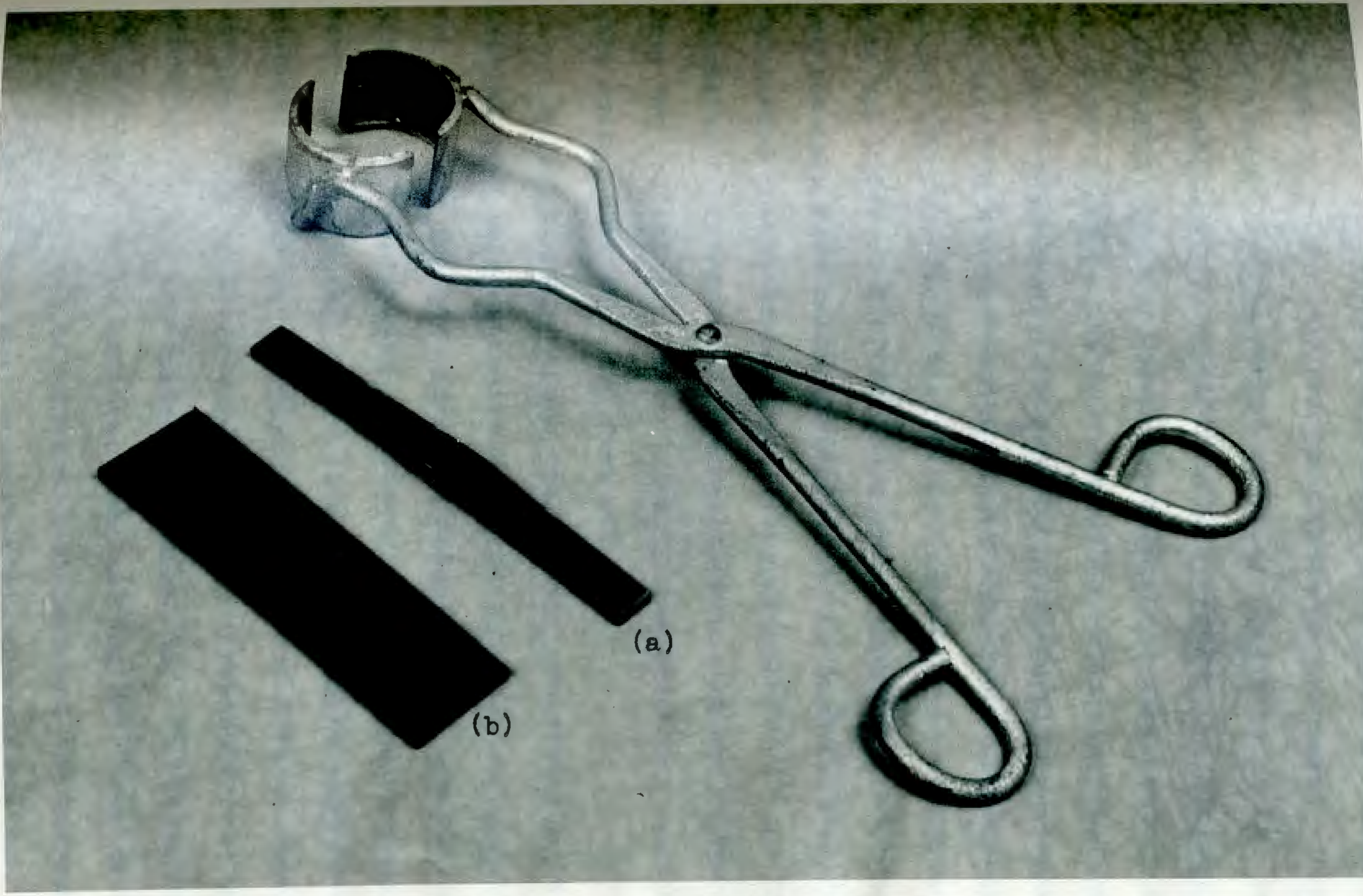

Figure 3. Forming tongs and plastic neck bands used in banding experiment. (a) is the original 3/8 by 5 inch band; (b) is the final 1 by 4 inch band.

upon nine penned birds, both hens and cocks, at the Peace Dale Shooting Preserve for observational purposes. It was found that the bands worked under the feathers of the neck and in this way became difficult to observe. While too small to go over the head, the bands were large enough for the bird to insert its lower mandible, with the result that the bird either broke the band by his struggles or worked an end into his mouth, causing injury, bleeding, and inability to eat. In the cocks the yellow bands did not contrast well with the white ring of feathers which surrounds the neck, and the dark blue bands blended into the dark neck coloring. Red seemed to be the most satisfactory color. In the first releases of pheasants at the Great Swamp, it was noticed that the red color remained clearly visible for a considerable distance as the bird flew off.

In the light of these preliminary observations it was decided that more extensive experimentation on band dimension and color was needed. This was undertaken in the fall of 1955 and the early spring of 1956 at the Hianlolan Game Farm, West Greenwich, Rhode Island with the permission of the foreman, Mr. George Wheatly. Five measurements of the head and neck were taken of three hens and three cocks one year old and of a similar number two years old. These measurements were compared and averaged. A clay model was made from the dimensions of the smallest head and the largest neck. Hens at both ages were sufficiently similar in measurements not to warrant separate models. By trying different sized bands on this model it was determined that a band four inches long by one inch wide would be large enough to fit comfortably around the bird's neck, wide enough not to be completely hidden by the feathers, yet small enough to prevent the bird from forcing his beak inside it. These bands were applied to three hens and three cocks, all two years of age. While the measurements taken of cocks did not show any appreciable differences in size, it was found during the actual banding that they would need a band slightly larger than that used on the hens. Other than this, the bands seemed to fit well and no apparent discomfort or difficulty in eating was observed in the birds. The bands had to be removed within a week however, because when the birds put their heads through the chicken wire of the cage the bands would catch and scrape the feathers off the back of the head. This situation would probably not be significant under field conditions.

In the middle of March, 1956, these bands were put on forty hens to be used in field trials at the Great Swamp previous to being released there. The purpose of this banding was to determine the ease with which the bands could be seen at various distances in the field. Because of a bad snow storm the trials were postponed and the birds held over with the intention of releasing them the second week in April. Considerable mortality was occurring in the pens, however, and it was found necessary to release the birds earlier than planned, at which time the author was not able to be present. Observations of the visibility of the bands were therefore not taken. The only indications of the actual visibility of the bands come from a conversation with Mr. Chester Whaley of the State Division of Fish and Game. Mr. Whaley stated that in a hen he observed several days in a row, the band was clearly visible without binoculars at a distance of several hundred yards, and that he thought it could be seen easily for a considerably longer distance. It also was reported from this last banding experiment that in future banding the edges of the bands would have to be smoothed because the sharp rough edges of the present bands caused irritation and occasional sores on the necks of the birds.

3. Observation of pheasants in the field

The stocked hens were observed weekly in the swamp from the fall of 1954 through the fall of 1955, and counts made both of stocked and of wild pheasants. Because of the nature of the area, these were total counts and all routine observations were restricted to the three planted areas and their immediate borders. The remainder of the reservation is heavily wooded upland, heavily wooded swamp or open marsh, and none of these habitats are traditionally favorable to the pheasant. These areas were observed only occasionally after the first surveys. The omission seemed justified in that there had been no reports of pheasants seen there and none were actually ever observed there during this project. The census method used was a modification of "walking a line"

(Trippensee, 1948). This method involves walking a definite route and counting all birds flushed, seen, or heard within either a limited or unlimited area on one or both sides of the "line," the exact method to be chosen to fit the situation. In this case the route went around the borders of the fields. Most of the fields were long and narrow, and all the pheasants flushed, seen, or heard were counted on both sides of the line. In this way it was thought possible to cover both the fields in which the birds might be feeding and the close cover in which they might be roosting or have taken refuge.

The counts were to have been classified into cock and hen, banded and unbanded categories. Throughout the spring and summer nests and clutches were to have been counted. In the fall before and after the hunting season, and from hunter returns, total counts were again to have been taken and an attempt made to separate the young birds from the adults. A number of methods are used in the field to accomplish age determinations: presence of the bursa of Fabricius, development of the spur, and rigidity of the lower mandible (Gower, 1939, Kimball, 1944, Kirkpatrick, 1944, Linduska, 1945). The development of the spur and rigidity of the mandible are probably the characters most easily used by inexperienced technicians.

4. <u>Analysis of the crop contents</u>

The crops of sixty-four pheasants shot in the 1955 Rhode Island hunting season and collected by the State

Division of Fish and Game were analyzed for food contents. Seventeen of these came from the Great Swamp, the rest from various other parts of Rhode Island. All were from banded cocks stocked for hunting except 16, which were wild. There were no wild cocks taken from the Swamp. Each crop had been tied in cheesecloth, labeled with the band number, site where collected, and sometimes the hunter and date taken. Occasionally the gizzard had been collected instead of the crop. The crops were preserved in ethyl alcohol.

The contents of each crop were examined and sorted qualitatively. The seed collection of the Rhode Island Division of Fish and Game of approximately 750 species was available for comparison and the seeds were identified, to species when possible. The volume of each type of seed present in each crop was measured by displacement in a ten milliliter graduated cylinder (Martin, 1946). The contents of all crops were then classified by volume in milliliters and frequency of occurrence for the whole state. The seventeen from the Great Swamp were then assembled in a separate table to determine whether there were significant differences in the food habits of the birds taken there from those shot in other parts of the state. The crops from the wild birds were then also separately tabulated. Because the stocked birds were game farm birds stocked only slightly previous to the hunting season, and probably fed on grains or a commercial feed mix, it was thought that they might take wild foods less readily than wild birds, and that their crop contents might therefore present a somewhat biased picture of the diet to be expected from a wild population. It was thought further that comparisons should be made with the small number of crops from wild birds.

5. Preparation and examination of soil samples

Six soil samples were collected from the various types found in the swamp and in the immediately surrounding area, and the gravels contained in them were examined for the presence of calcium containing minerals. Two hundred grams of samples no. 1 and no. 6, and 100 grams of the remaining samples were weighed out (wet weight) and washed in the following manner. The sample was placed in a beaker and stirred rapidly in water at a depth of four inches. Sodium hydroxide solution was added to assist in breaking up the soil lumps. The mixture of soil and water was allowed to settle for 45 seconds, and the water then decanted. This process was repeated until the decanted water was clear and it was possible to read the label on a bottle through it. This is a rapid method for the extraction of sands and gravels from soils set up by the Bureau of Soils and modified by Professor Clarence E. Miller of the Department of Geology, University of Rhode Island. Each washed soil sample was filtered, dried and then sieved into four fractions, +10, +20, +60 and -60. These figures indicate the mesh size of the various sieves. Each fraction was weighed and the dry weight percentage of the total sample was calculated. The fractions were then examined under a microscope, the smaller mesh ones being examined under a compound microscope using polarized light, to assist in differentiating the various minerals. The dominant minerals present were identified together with an approximate estimate of their relative abundance.

6. Methods used in the vegetation survey

A rough quantitative survey of the plant species in the various ecotypes found in the Great Neck area of the reservation was taken using the square yard quadrat method. In the preliminary work, however, it was found that such a method would not give reliable results because of clone formation and the clumping together of many of the common wild plants. A larger area, perhaps a ten-foot square quadrate, would need to be taken to produce meaningful quantitative results, but it was felt that this type of plant survey would not justify the time consumed in taking this inventory. Therefore, in the qualitative survey of the common species present in the area, the dominant species were merely noted.

The qualitative survey was intended to give a list of the common plant species which were available to the pheasant during the times of critical food consumption, that is, in the fall and winter months. It was therefore undertaken in the late October of 1955 and early spring of 1956. It was accomplished by inspection of the various ecotypes present. Dr. Elmer Palmitier of the Rhode Island University Department of Botany assisted in the identification of the unknown species. The list is by no means intended to be complete, but only a record of those plants readily available for food at that time, either by the presence of seeds or foliage.

7. Collection and treatment of weather data

The volumes of Climatological Data published by the Weather Bureau of the United States Department of Interior were used to collect weather data for eight stations, two in Iowa, two in Nebraska, two in South Dakota and two in Rhode Island. These three central United States states make up a large part of the prime pheasant country; one station was chosen in the eastern, and one in the western part of each state in order to try and eliminate the possible changes of climate from east to west. Daily maximum and minimum temperatures together with the monthly averages were recorded for April through August for 10 years (1945-1954) for Iowa, Nebraska and South Dakota, and for 15 years (1940-1954) for Rhode Island. It had been planned to take data for 15 years for all stations, but the period from 1940 through 1944 was not available for the three central states. The period of 15 years was chosen to include the years of pheasant population decline between 1945 and 1948 plus a period of normal population levels on either side. Each month was classified according to the number of days where maximum and minimum temperatures fell below 50°, 40° and 32°. The averages for these classifications for all years were then computed.

Monthly precipitation, the number of days per month on which any precipitation occurred, and the number of days per month on which 0.01 inches or more precipitation occurred were recorded, and the monthly averages were found for all stations for the yearly periods listed above. Monthly precipitation averages for each of the four states as a whole were also available for a considerable period of years. The amounts for the last 56 years were recorded and the mean and standard deviation for April through August in each state were calculated.

The average percentage of monthly sunshine, and the number of clear, partly cloudy and cloudy days, already computed in the <u>Climatological Data</u>, were observed and compared for Iowa and Rhode Island.

Daily weather records for Providence, Rhode Island were consulted at the weather station at the Theodore Francis Greene Airport outside of Providence to find the duration in hours of storms in this area for the late spring and summer months. For the purposes of this study, a storm was considered to have begun in the hour when 0.01 inches or more of precipitation had fallen and to have ended when 11 minutes or more of sunshine per hour was recorded. These storm records for the 11 years from 1940 to 1950 were then classified for duration, 12 hours or less, 13 through 24 hours, 25 through 36 hours, longer than 36 hours, and longer than 48 hours.

A Bendix recording Aerograph was purchased by the Department of Zoology for use in recording weather data at the swamp. The clockwork had a seven day cycle; variations in barometric pressure, relative humidity and temperature were recorded by writing pens upon a revolving drum on specially printed charts (Figures 4 and 5). A weather proof shelter was designed and built to house the instrument and set into the ground so that the bottom of the instrument inside would be three inches above the surface of the ground. It was placed in the south-east corner of an old hay field in area II, away from the passage of tillage machinery, and somewhat sheltered from wind by a low border growth on the southern and eastern sides. The instrument was set out in June, 1955, and recorded through October when the clockwork, which had not been performing the full seven day cycle for several weeks stopped running altogether.

Dr. Robert C. Wakefield of the University of Rhode Island Agricultural Experiment Station had also been recording a series of daily temperature measurements for the year of 1955 at the University Turf Plots at the three-inch and five-foot levels above the ground. (Five feet is the standard weather bureau height for weather measurements.) The data from the few months exposure at the swamp were sufficient to use as a check with Dr. Wakefield's data, and the three-inch level temperatures at the two habitats were compared using range and monthly averages.

The five-foot and three-inch data (both taken at approximately the same place) from Dr. Wakefield's records were then compared in order to determine whether there was any significant differences in the temperature climate at

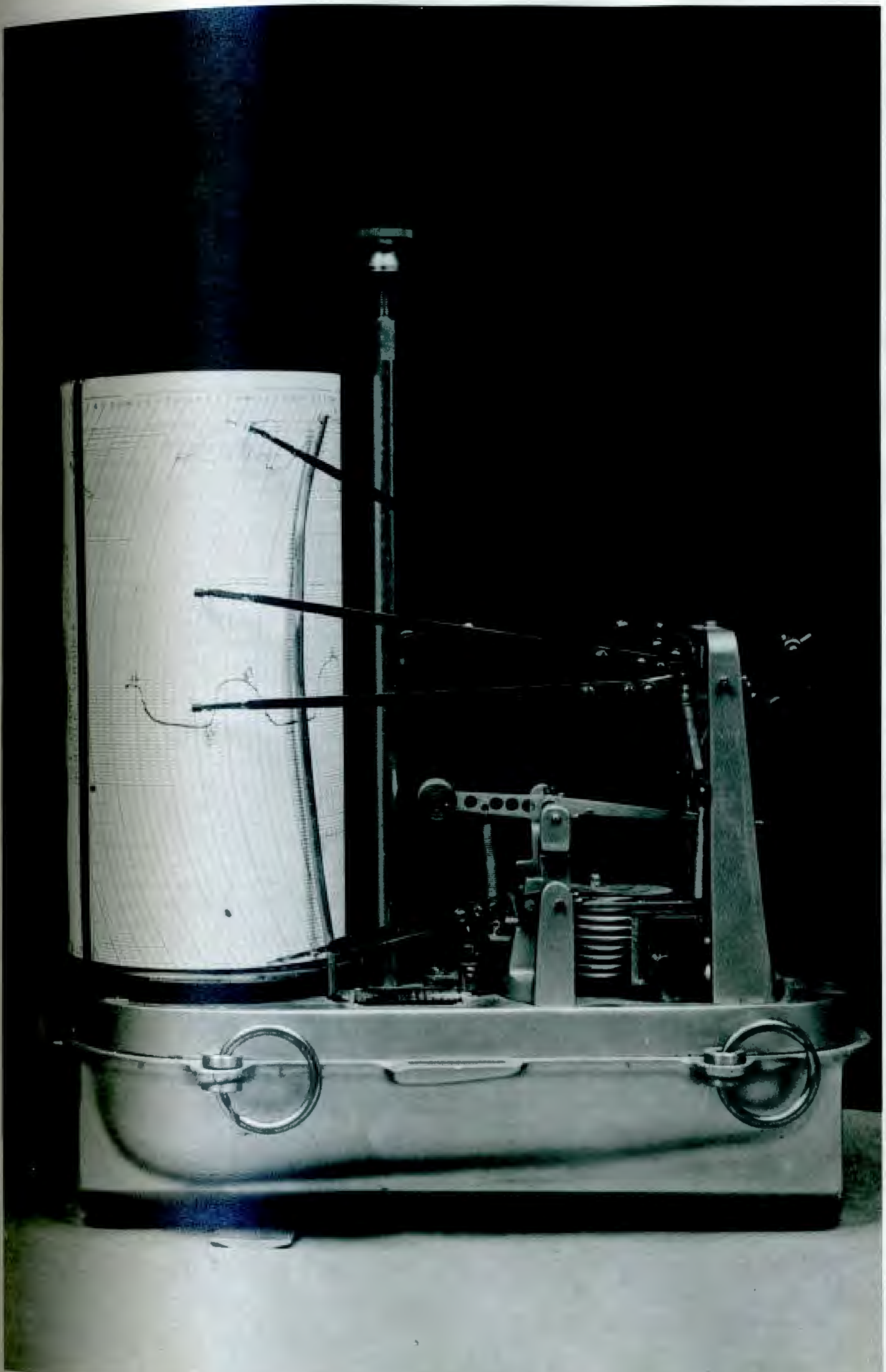

Figure 4. The Bendix Aerograph

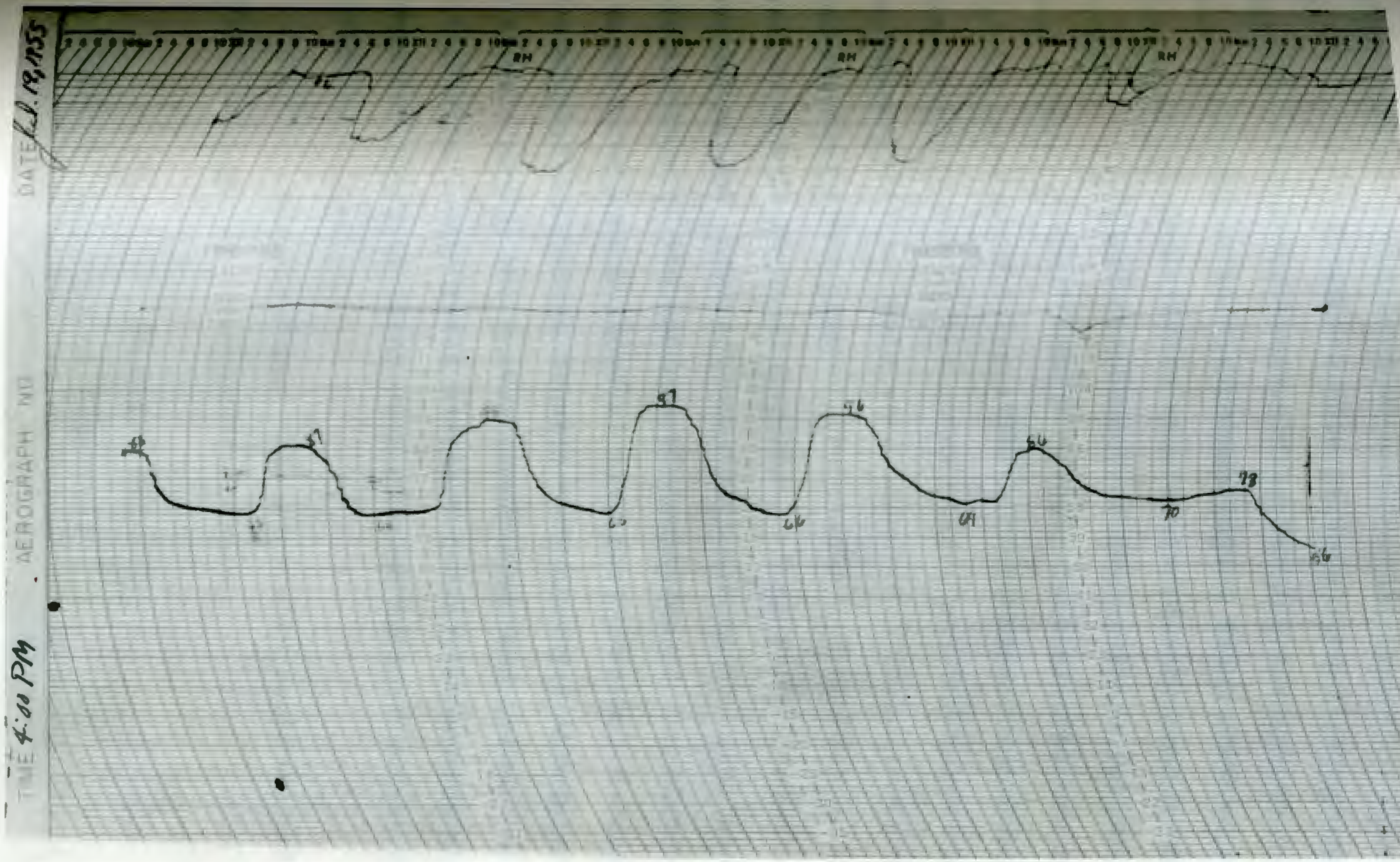

Figure 5. A sample chart from the Bendix aerograph showing continuous readings for almost seven days. The top line shows relative humidity, the middle line shows barometric pressure, and the bottom line shows temperatures, at three inches above the ground.

three inches, the actual habitat of the pheasant chick, and at five feet. These two sets of data were first graphed, the maximum and minimum temperatures for the two levels for each day of the months April through August being plotted and connected horizontally to make a line graph showing the actual course of temperatures throughout the month in relation to each other. The difference between temperatures was noted and the mean monthly variations of the three-inch level from the five-foot level, the modal class, and the quartile distribution about the mode were computed. These tests were expressed in a bar graph. The standard deviation is usually used as a measure of dispersion in such work; preliminary testing showed, however, that it could not be used since the distribution of the amounts of deviation of the three-inch temperatures around those at five feet were not normally distributed. Although usually they arranged themselves in a sigmoid curve, the curves were peaked and skewed to such a degree that calculated standard deviations showed a large amount of positive error when checked against actual distribution counts.

All weather data were then carefully compared and the significance of the results discussed.

B. Data and Results

1. Field observations of pheasants

In all of the weekly field trips undertaken in this investigation, only three pheasants, one cock and two hens, were observed in the swamp area except at the times immediately following fall stocking of cocks for the hunting season, when a large number of cocks were observed in area II. Banded hens and breeding pairs were occasionally seen by employees of the State Division of Fish and Game who were working daily in the swamp, and two banded hens were reported from the vicinity of Peace Dale, Rhode Island, about two and one half miles away. As the project progressed, it became apparent that if sufficient data were to be collected to be significant, it would be necessary to spend at least four days a week in the area. Because this was not possible, it was felt that this part of the project should be abandoned. The only significant fact that could be drawn from these observations is that ringnecked pheasants do not thrive in great abundance in the area, nor do those released remain there in large numbers for a very long period of time.

2. Crop analysis

The results of the crop analysis are expressed in Tables 2, 3, and 4. Of 64 crops examined, 10 were completely empty. Three of these empty crops came from wild pheasants, and two were from Great Swamp birds; the rest came from other parts of Rhode Island.

In all three tables the percentage volume of cultivated grains was greater than the percentage of occurrence in the crops. Of the 14 crops taken from Great Swamp birds, all contained cultivated grains; of the 16 crops from wild pheasants, 10, and of the remaining crops, 17 also contained cultivated grains. Of 54 crops containing food 41 had

Table 2. Analysis by volume and occurrence of foods from the crops of sixty-four ring-necked pheasants collected in November, 1955, in Rhode Island.

Scientific name	Common name	Total volume (milliliters) in all crops	Percentage total volume of all foods	Total times occurred	Percentage of total occurrence
Flora:					
*Zea Mays, L.	Corn	163.76	34.36	18	27.18
Unidentified	Brown & green leaf matter	7.48	1.56	17	26.56
Unidentified	Grass	6.20	1.30	15	23.44
*Fagopyrum esculentum, Moench.	Buckwheat	75.12	15.76	13	20.31
*Setaria italica, (L.) Beauv.	Golden millet	34.55	7.25	12	17.72
*Echinochloa frumentaceae, (Roxb.) Link.	Japanese millet	80.78	16.95	10	15.65
*Sorgum sp.	(Food patch mix)	3.60	0.76	7	10.94
Amaranthus retroflexus, L.	Pigweed	1.20	0.25	7	10.94
*Triticum aestivum, L.	Wheat	28.80	6.04	6	9.37
*Unidentified	Tubers(potatoes)	37.02	7.77	4	5.25
Ambrosia artemisiifolia, L.	Common ragweed	1.49	0.31	4	5.25
Impatiens biflora, Walt.	Snapweed	0.15	0.03	3	4.69
Myrica pensylvanica, Loisel.	Bayberry	20.27	4.25	3	4.69
Alnus sp.	Alder catkins	0.80	0.17	2	3.13
Amelanchier sp.		T	less than 0.01	2	3.13
Polygonum punctatum, Ell.	Water smartweed	0.10	0.02	2	3.13

Table 2. (cont.)

Rhus radicans, L.	Poison ivy	0.75	0.16	2	3.13
Alnus rugosa, (Du Roi) Spreng.	Speckled alder	T	less than 0.01	1	1.56
Alnus serrulata, (Ait) Willd.	Smooth alder	T	" " 0.01	1	1.56
Bidens frondosa, L.	Beggar tick	0.30	0.06	1	1.56
Chenopodium album, L.	Lamb's-quarters	T	" " 0.01	1	1.56
Eupatorium sp.	Joe-Pye-weed or Boneset	T	" " 0.01	1	1.56
Polygonum sagittatum, L.	Arrow-leaved tear thum	T	" " 0.01	1	1.56
Prunus serotina, Ehrh.	Wild black cherry	0.48	0.10	1	1.56
Quercus sp.	Oak (acorn)	1.70	0.36	1	1.56
Rumex Acetosella, L.	Sheep sorrel	T	" " 0.01	1	1.56
Sanguisorba officinales, L. (?)	Red pucoon	T	" " 0.01	1	1.56
Solanum nigrum, L.	Horse nettle	2.23	0.47	1	1.56
Solidago sp.	Golden rod	T	" " 0.01	1	1.56
Trifolium sp.	Clover (leaf)	T	" " 0.01	1.	1.56
Unidentified	Seeds	T	" " 0.01	8	12.50
Unidentified	Buds (red maple?)	T	" " 0.01	1	1.56
Fauna:					
Aphidae	Aphids	T	" " 0.01	2	3.13
Acrididae	Grasshopper	0.65	0.14	1	1.56
Araneae	Spider	T	" " 0.01	1	1.56
Lepidoptera	Caterpillar	T	" " 0.01	2	1.56
Coleoptera	Beetle	T	" " 0.01	1	1.56
Limax sp.	Common garden slug	0.65	0.14	1	1.56
Mantidae	Mantis egg case	7.03	1.53	1	1.56
Unidentified	Insect	T	" " 0.01	1	1.56
Unidentified	Insect eggs	T	" " 0.01	1	1.56
TOTAL		476.55	----	156	----

Table 3. Analysis by volume and occurrence of foods from the crop of seventeen ring-necked pheasants collected from the Great Swamp Wildlife Reservation, Rhode Island, November, 1955.

Scientific name	Common name	Total volume (milliliters) in all crops	Percentage total volume of all foods	Total times occurred	Percentage of total occurrence
Flora:					
*Fagopyrum esculentum Moench.	Buckwheat	58.65	44.75	7	41.18
*Zea Mays L.	Corn	28.65	21.86	6	35.29
*Setaria italica (L.) Beauv.	Golden millet	14.60	11.14	5	29.41
*Echinochloa frumentaceae (Roxb.) Link.	Japanese millet	11.27	7.60	5	29.41
*Unidentified	Tubers(potatoe?)	9.30	7.10	1	5.88
Unidentified	Leaves	3.60	2.75	6	35.29
*Sorgum sp.	(Food patch mix)	1.50	1.14	1	5.88
Amaranthus retroflexus L.	Pigweed	1.20	0.92	4	23.53
Unidentified	Grass	1.00	0.76	3	17.65
Alnus regosa (Du Roi) Spreng.	Speckled alder	T	less than 0.01	1	5.88
Amelanchier sp.	Shad bush	T	" " 0.01	1	5.88
Solidago sp.	Goldenrod	T	" " 0.01	1	5.88
*Trofolium sp.	Clover leaf	T	" " 0.01	1	5.88
*Triticum aestivum L.	Wheat	T	" " 0.01	1	5.88
Fauna:					
Aphidae	Aphids	T	" " 0.01	1	5.88
Araneae	Spider	T	" " 0.01	1	5.88
Unidentified	Insect	T	" " 0.01	1	5.88
TOTAL		131.05	-----	44	-----

Table 4. Analysis by volume and occurrence of foods from the crops of sixteen wild ring-necked pheasants collected in Rhode Island, November, 1955.

Scientific name	Common name	Total volume (milliliters) in all crops	Percentage total volume of all foods	Total times occurred	Percentage of total occurrence
Flora:					
Unidentified	Tuber (potato?)	26.80	23.27	3	18.75
**Zea Mays*, L.	Corn	25.27	21.95	3	18.75
Myrica pensylvanica Liosel.	Bayberry	20.27	17.60	3	18.75
**Triticum aestivum* L.	Wheat	19.30	16.76	4	25.00
**Echinochloa frumentaceae*(Roxb.) Link.	Japanese millet	7.87	6.83	2	12.50
Unidentified	Grass	5.20	4.52	4	25.00
Solanum carolinense L.	Horse mettle	2.23	1.94	1	6.25
**Sorghum* sp.	(Food patch mix)	2.10	1.82	1	6.25
Quercus sp.	Oak (acorn)	1.70	1.48	1	6.25
Ambrosia artemisiifolia L.	Common ragweed	1.49	1.28	3	18.75
**Setaria italica* (L.) Beauv.	Golden millet	1.00	0.87	2	12.50
Rhus radicans L.	Poison ivy	0.75	0.65	2	12.50
Prunus serotina Ehrh.	Wild black cherry	0.48	0.42	1	6.25
Bidens frondosa L.	Beggar tick	0.30	0.26	1	6.25
Unidentified	Leaves	0.20	0.17	5	31.25
**Fagopyrum esculentum* Moench.	Buckwheat	0.17	0.15	1	6.25
Amaranthus retroflexus L.	Pigweed	T	less than 0.01	1	6.25
Impatiens biflora Walt.	Snapweed	T	" " 0.01	1	6.25

Table 4. (cont.)

Rumex Acetosella L.	Sheep sorrel	T	less than 0.01	1	6.25
Sanguisorba officinales L. (?)	Red pucoon	T	" " 0.01	1	6.25
Unidentified	Buds (red maple?)	T	" " 0.01	1	6.25
Unidentified	Seeds	T	" " 0.01	5	31.25
Fauna:					
Lepidoptera	Caterpillar	T	" " 0.01	1	6.25
TOTAL		115.15	----	48	----

cultivated grains in them, with an average of 9.43 milliter per bird. Since the average total volume of contents based on 54 crops is 8.83 milliliter, it appears that those birds that fed on grains fed heavily.

Compared with the results shown for cultivated grains, the percentages of occurrence for wild seeds are always much larger than the percentages of volume. Six of the Swamp birds, eight of the wild birds, and two of the remaining birds ate wild seeds. This made a total of 16 out of 54 crops containing food, with an average of 0.02 milliliter per crop. Reference to Tables 2, 3, and 4 show that many of these species of wild seeds occurred only once, in trace amounts. Weed seeds were found in the crops of 25% of all the pheasants examined, and also in very small amounts, 0.68% of the total volume.

Animal matter, as one would expect in November, composed an insignificant part of the food, both by volume and occurrence. The large volume shown in Table 3 is present largely because of the occurrence of a whole praying mantis egg case in one crop.

3. <u>Contents of soil samples</u>

The probable soil type for each sample is shown below:

Sample no. 1 -- Narragansett stoney loam, level phase.

Sample no. 2 -- Same as no. 1.

Sample no. 3 -- Gloucester stoney very fine, sandy loam.

Sample no. 4 -- Narragansett stoney loam.

Sample no. 5 -- Gloucester stoney, fine, sandy loam.

Sample no. 6 -- Bridghampton very fine, sandy loam.

These probable soil types were taken from the soil map found in the United States Department of Agriculture bulletin of the soil types in Kent and Washington Counties, Rhode Island (Roberts, Knoblauch, Madison, and Hendrick, 1939). The major constituent of all gravels from all samples was quartz. Orthoclase feldspar was the mineral ranking second in abundance in all samples, making up from about one-tenth to one-half the volume of the quartz. There were no other minerals occurring in any of the samples in larger than trace amounts (less than 0.1 grams). All fractions of samples five and six contained large amounts of cinders, which is to be expected, since they both were taken within approximately 50 feet of the tracks of the New Haven Railroad. Biotite was the trace mineral found in largest amounts, occurring in the +20 fraction of no. 2, the -60 fraction of no. 3, all fractions of no. 4, the +60 and -60 fractions of no. 5, and the +20, +60 and -60 fractions of no. 6. Traces of black carboniferous schist were found in all fractions of all samples. Magnetite was found in all fractions of no. 1, no. 2 and no. 3. A very few crystals were present in all of the fractions except the +10 fraction of no. 1 and in the +60 and the -60 fractions of no. 3. One olivine crystal was found in the +60 fraction of no. 5 and a few zircon crystals in the +60 and the -60 fractions of no. 1. The only calcium containing minerals found in these gravels were black schist and chlorite, both occurred in trace amounts.

4. Survey of vegetation

Table 6 gives the lists of the principal species found in the various habitats occurring over most of the Great Neck, during late fall and winter. Many of the woody shrubs, the two species of Smilax and particularly the ericaceous shrubs are well represented in all areas. Asterisks indicate those plants occurring in greatest abundance, making up perhaps 95% of the plants, in each habitat.

5. Analysis of precipitation

The average monthly amounts of precipitation of six areas for the period of 56 years, from 1900 to 1955 are summarized in Table 7, accompanied by the computed standard deviations. The United States Weather Bureau compiles New England data into southern and northern regions, and Rhode Island is represented in this table by "Southern New England". The other five states in the table represent the principal states in which high populations of pheasants occur. Plus and minus the standard deviation on either side of the mean includes the limits of variation in precipitation occurring statistically in about 66 years out of 100, or two-thirds of the time. Table 7 indicates that the amount of precipitation in both Iowa and Southern New England varies considerably about the mean from year to year, ranging statistically from none (a negative value here has no meaning) to nearly 18 inches in August in Iowa, and to almost 25 inches in Southern New England in April. An examination of the records shows that these values are somewhat distorted, since the actual

Table 6. Principal Fall and Winter Plant Species in the Great Neck.

Scientific name	Common name
Forest species:	
*Acer rubrum L.	Red maple
*Alnus sp.	Alder
*Betula lutea Michx. f.	Yellow birch
*Betula populifolia Marsh.	Gray birch
Clethra alnifolia L.	Sweet pepper bush
Fraxinus sp.	Ash
*Gaultheria procumbens L.	Wintergreen
*Gaylussacia frondosa (L.) T. and G.	Dangleberry
Hamamelis virginiana L.	Witch-hazel
*Ilex glabra (L.) Gray	Inkberry
*Ilex laevigata (Pursh) Gray	Smooth winterberry
Ilex opaca Ait.	American holly
Kalmia angustifolia L.	Sheep laurel
*Kalmia latifolia L.	Mountain laurel
Leucothoe racemosa (L.) Gray	Fetter-bush
*Lycopodium sp.	Club moss
Lyonia ligustrina (L.) DC.	Male berry
*Pinus rigida Mill.	Pitch pine
*Pinus strobus L.	White pine
*Quercus alba L.	White oak
*Quercus rubra L.	Red oak
*Quercus velutina Lam.	Black oak
Rhododendron viscosum (L.) Torr.	Swamp azelia
*Rubus flagellaris Willd.	Dewberry
Sassafras albidum (Nutt.) Nees	Sassafras
Smilax glauca Walt.	Cat briar
*Smilax rotundifolia L.	Bull briar
Spirea tomentosa L.	Steeple-bush
Solidago rugosa Ait.	Goldenrod
Solidago spp.	Goldenrods
*Vaccinium atrococcum (Gray) Heller	High bush blueberry
*Vaccinium corymbosum L.	High bush blueberry
Vitis sp.	Grape
Unidentified	Grass sp.
Abandoned fields and old hay fields:	
Alechia maretima	
*Andropogon virginicus L.	Broom sedge
*Aristida purpurascens Poir.	Needlegrass
Aronia arbutifolia (L.) L. f.	Red chokeberry
Aster viminius Lam.	Aster
Chenopodium sp.	Goosefoot (Pigweed)
*Cyperus spp. (3)	Sedges

Table 6. cont.

*Dactylis glomerata L. (?)	Orchard grass
*Danthonia spicata (?) (L.) Beauv	Poverty grass
Eragrostis spectabalis (Pursh) Steud	Petticoat climber
Eupatorium sp.	Bone set
*Festuca capillata (?) Lam.	Fescu-grass
Gnaphalium sp.	Everlasting
*Juncus greenei Oakes and Tuckerm.	Sedge
*Juncus sp.	Rush
Lignus alba	
*Medicago sativa L.	Alfalfa
*Panicum capillare L. (?)	Witch grass
Paspalum sp.	
*Phleum pratense L.	Timothy
*Potentilla sp.	Cinquefoil
Rosa sp.	Rose
*Rubus flagellaris Willd.	Dewberry
Smilax glauca Walt.	Cat briar
Solidago puberula Nutt.	Goldenrod
*Solidago rugosa Ait.	Goldenrod
Solidago tenuifolia Pursh	Goldenrod
*Trichostema dichotomum L.	Bluegrass

Also scattered species of shrubs and trees found in brush areas.

Hedge rows and brush areas:

*Acer rubrum L.	Red maple
*Amelanchier sp.	Shad bush
*Betula populifolia Marsh.	Gray birch
*Comptonia peregrina (L.) Coult.	Sweet fern
*Gaylussacia baccata (Wang.) K. Koch	Black huckleberry
Ilex verticillata (L.) Gray	Winterberry
Juniperus virginiana L.	Red cedar
*Kalmia angustifolia L.	Sheep laurel
*Myrica pensylvanica Loisel.	Bayberry
Nyssa sylvatica Marsh.	Tupelo tree
*Pinus rigida Mill.	Pitch pine
*Prunus serotina Ehrh.	Wild black cherry
Pyrus malus L.	Apple
*Quercus illicifolia Wang.	Scrub oak
Quercus palustris	Pin oak
Quercus velutina Lam.	Black oak
*Rhus radicans L.	Poison ivy
*Rubus flagellaris Willd.	Dewberry
Rubus sp.	Blackberry
Sassafras albidum (Nutt.) Nees	Sassafras
Smilax glauca Walt.	Cat briar
*Smilax rotundifolia L.	Bull briar
*Vaccinium angustifolium Ait.	Low bush blueberry
*Vaccinium atrococcum (Grau) Heller	High bush blueberry
*Vaccinium corymbosum L.	High bush blueberry
*Vaccinium vacillans Torr.	Low bush blueberry

Grass species found in fields.

Table 6. cont.

Food patch mix and cultivated fields:

Brassica Rapa L.	Rape
Echinochloa frumentaceae (Roxb.)Link.	Japanese millet
Fagopyrum esculentum Moench.	Buckwheat
Helianthus sp.	Sunflower
Setaria italica (L.) Beauv.	Golden millet
Setaria sp.	Hungarian millet
Sorghum sp.	Kafir corn
Sorghum vulgare Pers.	Ambercane
Elymus sp.	Rye
Trifolium sp.	Clover
Triticum aestivum L.	Wheat
Zea Mays L.	Corn

Table 7. Average monthly precipitation in inches for April through August during the period from 1900 to 1955.

	Iowa	Michigan	Minnesota	Nebraska	South Dakota	Southern New England
April						
Mean	2.74	2.51	1.80	2.31	1.90	3.81
May						
Mean	3.97	3.12	3.15	3.35	2.86	3.57
June						
Mean	4.76	3.21	4.06	3.70	3.60	3.55
July						
Mean	3.54	3.33	2.91	2.89	2.43	3.56
August						
Mean	3.73	3.36	2.85	2.76	2.24	4.03

maximum rainfall for Iowa occurred in June, 1947, with 10.39 inches, while in Southern New England, the maximum recorded rainfall occurred in August, 1955, with 13.67 inches. The value of the standard deviation is that it shows the relative variation in precipitation a large part of the time for different areas, by indicating that New England and Iowa may vary from being very wet to very dry in all months from year to year, while the other four states, on the average receiving less rainfall, fluctuate less from year to year, and also from month to month.

Table 8 shows that Kingston and Providence average fewer days of total precipitation than stations in good pheasant country for all months except May. Of measurable precipitation (0.01 inches or more), however, Rhode Island has about the same number of days, approximately 11, as the other stations in April, May and June; Providence and Rapid City have more in July. Data concerning the number of days for total rainfall were computed from the records for ten years for all stations except those in Rhode Island, for which the records for 15 years were used. Data already calculated from the 1955 Annual Report of Climatological Data were taken for days on which measurable precipitation occurred and although the number of years on which these averages were based was not stated; the record in all cases goes back at least 50 years.

It was felt that a comparison of the way in which precipitation occurred and the duration of precipitation might show significant differences between productive and unproductive

Table 8. Average number of days of precipitation for May through August.

Station	Average number of days during which a trace or more of precipitation fell. (1945-1954)				Average number of days during which 0.01 inch or more of precipitation fell. (1900-1954)			
	May	June	July	August	May	June	July	August
Webster City, Iowa	13	13	10	11				
Davenport, Iowa					12	11	8	9
Sioux City, Iowa					11	11	9	9
Cedar Rapids, Iowa	18	17	14	13				
Lincoln, Nebraska	11	11	8	11	11	11	9	10
North Platte, Nebraska	16	12	13	13	11	10	9	9
Huron, South Dakota	16	17	15	14	10	11	9	9
Rapid City, South Dakota	18	18	15	15	9	11	14	15
Kingston, Rhode Island	12	10	10	10				
Providence, Rhode Island	17	13	13	12	11	10	10	9

areas. This material is somewhat more difficult to express than actual rainfall measurements, Table 9 compares the average number of days that were clear, partly cloudy and totally cloudy for May, June, July and August for six stations. Here are the first differences in weather between Rhode Island and the other stations. For the months of June, July and August, the two Rhode Island stations average a higher number of totally cloudy days and a considerably fewer number of clear days. Table 9 also shows the average percentage of sunshine per month for Iowa and Rhode Island. These figures are based on the number of hours of sunshine possible from sunrise to sunset. Here again there is a considerable difference in that Rhode Island averages, in all cases, less sunshine than Iowa: April 4%, May, 6%, June and August, 10% and in July, 15%. Translated into whole days, this means that on the average, in April and May, Iowa has slightly less than 18 days of sunshine, Rhode Island, about 16; in June and August, Iowa has about 21 days and Rhode Island about 18; in July, Iowa has about 23 days, and Rhode Island again about 18.

Detailed weather records at the Theodore Francis Greene Airport, Providence, yielded detailed data for each storm in the area for a period of 11 years from 1940 through 1950. These data are recorded in Table 10 and summarized in Table 11. The date on which rain of 0.01 inches or more per hour fell is recorded on the left of each column with the number of hours following this rain opposite the date until 11 or more minutes per hour of sunshine was noted, indicating clearing of the

Table 9. Average number of clear, partly cloudy and cloudy days for Iowa, Nebraska, South Dakota and Rhode Island and percent sunshine for Iowa and Rhode Island, during the months May through August.

	May			June			July			August		
	clear	partly cloudy	cloudy	clear	partly cloudy	cloudy	clear	partly cloudy	cloudy	clear	partly cloudy	cloudy
North Platte	10	11	10	12	12	6	15	12	4	14	12	5
Lincoln	8	11	12	10	12	8	13	12	6	12	12	7
Sioux City	8	11	12	9	12	9	14	11	6	13	11	7
Huron	10	12	9	11	12	7	14	13	4	14	12	5
Rapid City	9	11	11	11	11	8	14	13	4	15	11	5
Providence	9	11	11	10	11	9	10	12	9	11	11	9

Percent Sunshine

	April	May	June	July	August
Iowa	58	62	69	76	70
Rhode Island	54	56	59	61	60

Table 10 - Dates Upon Which Storms Occurred and the Number of Hours Duration of Each Storm in Providence, Rhode Island, for the Months of Ma y Through August, 1940 Through 1950.

1940 Date*	1940 Hours**	1941 Date	1941 Hours	1942 Date	1942 Hours	1943 Date	1943 Hours
May							
1	97	1	33	4	7	3	44
17	25	5	12	6	89	6	9
20	156	8	63	13	9	8	10
28	29	17	12	17	30	11	48
31	31	23	7	22	48	14	5
		24	17	31	13	18	37
		27	3			20	16
		28	5			21	28
		28	3			26	19
						27	1
						29	13
June							
10	77	1	32	2	64	1	24
13	3	4	42	7	16	3	12
14	2	14	66	14	29	10	10
19	8	16	7	17	16	14	11
24	66	16	7	21	19	17	9
27	3	18	8	23	14	29	18
28	17	20	7	28	15		
		23	19				
July							
1	9	1	10	2	38	5	26
2	3	2	8	6	2	7	54
3	35	3	35	8	3	18	7
5	4	6	9	11	9	22	3
11	46	7	26	14	4	26	6
20	74	12	49	18	33	29	5
26	6	17	58	27	19	29	10
		23	6	31	15		
		24	3				
		25	3				
		28	20				
		30	51				
August							
7	13	12	2	9	49	12	9
18	45	15	18	13	25	13	10
23	14	19	25	14	4	27	20

* Date on which 0.01 or more inches of rain fell in one hour.
**Number of hours of duration of storms from the first hour in which 0.01 or more inches of rain fell until the occurrence of 11 or more minutes of sunshine per hour.

(Table 10 cont.)

Month	1940 Date - Hours	1941 Date - Hours	1942 Date - Hours	1943 Date - Hours
August	26 - 9	23 - 13	17 - 11	
	29 - 43	25 - 11	17 - 9	
		26 - 5	23 - 9	
		31 - 13		

Month	1944 Date - Hours	1945 Date - Hours	1946 Date - Hours	1947 Date - Hours
May	7 - 3	2 - 40	5 - 21	1 - 85
	7 - 9	6 - 2	7 - 14	5 - 15
	22 - 61	6 - 15	9 - 12	7 - 16
		8 - 14	12 - 12,12	14 - 28
		10 - 17	14 - 13	18 - 21
		13 - 15	17 - 38	20 - 7,62
		17 - 6	21 - 22	25 - 16
		17 - 55	26 - 64	
		25 - 11		
		27 - 12		
		28 - 9		
		30 - 4		
June	10 - 25	3 - 30	1 - 36	3 - 12
	15 - 27	5 - 25	4 - 14	8 - 32
	16 - 6	6 - 1	5 - 12	18 - 15
	19 - 15	8 - 2	8 - 8	19 - 2
	24 - 48	8 - 1	11 - 19	24 - 25
		16 - 11	13 - 2	25 - 35
		15 - 8	18 - 4	
		17 - 5	18 - 15	
		20 - 11	21 - 14	
		21 - 12		
		26 - 24		
July	4 - 1[illegible]	2 - 3	2 - 6	5 - 8
	10 - 11	2 - 1	6 - 7	8 - 4
	16 - 12	2 - 13	9 - 31	9 - 2
	21 - 9	6 - 12	20 - 59	17 - 5
	27 - 11	10 - 13	23 - 16	19 - 22
	30 - 1	14 - 11		21 - 38
	31 - 3	15 - 20		28 - 31
		20 - 2		
		29 - 9		
August	3 - 9	6 - 21	1 - 43	7 - 6
	5 - 17	15 - 18	7 - 26	8 - 14
	17 - 13	24 - 51	10 - 8	9 - 22
		31 - 1	13 - 35	16 - 34
			16 - 13	20 - 46
			17 - 12	26 - 65
			19 - 23	
			23 - 26	
			27 - 28	
			29 - 18	

(Table 10 cont.)

	1948		1949		1950	
	Date	Hours	Date	Hours	Date	Hours
May	5	17	2	2	1	26
	7	20	3	7	6	8
	10	12	10	10	10	29
	12	66	12	26	16	9
	16	20	14	12	18	48
	17	13	20	24	24	39
	18	16	22	16	29	23
	21	4,11	24	11		
	26	14	27	27		
	30	53				
June	5	6	25	9	1	28
	7	25			3	13
	8	59			10	8
	12	7			14	16
	13	29			17	13
	17	10			19	20
	19	10			21	5
	23	22			24	14
					25	10
					27	10
July	1	1	10	17	1	6
	1	1	13	8	3	5
	1	9	17	19	4	4
	5	13	20	14	4	15
	6	1	25	2	5	13
	6	18			10	14
	13	25			12	27
	23	15			13	9
	27	2			16	25
	28	14			20	21
	12	3				
August	12	8	2	15	1	70
	12	3	3	36	11	16
	13	13	11	60	19	40
	17	13	24	13	29	6
	30	16	29	7	29	11
					31	29

Table 11. Summary of number and duration of storms occurring in Providence, Rhode Island, for the months April through August, 1940 through 1950.

	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
Storms lasting 12 hours or less	9	19	10	15	10	21	11	7	14	9	13
Between 12 and 24 hours	3	6	8	6	2	12	12	10	16	9	10
Between 25 and 36 hours	4	5	3	2	2	2	6	5	3	3	6
Over 36 hours	8	6	5	3	3	2	4	5	3	1	4
Over 48 hours	4	4	2	1	2	1	2	3	3	1	1

storm and the beginning of conditions which would possibly dry off the area wet by the storm. In some cases, the storm would clear over-night but wet conditions would persist until the morning, when the sun arose, and these night hours without precipitation were therefore counted as part of the storm. The estimates recorded are probably conservative in indicating the duration of extremely wet conditions, because very often while the sun shone after the storm more than ten minutes, cloudy conditions returned shortly. In many cases, then, very wet conditions continued to exist for some hours longer than indicated. In every season, including very dry ones of 1944, 1947 and 1949, there was at least one storm lasting more than two days (48 hours) following a measurable amount of rain and at least five storms lasting longer than one day (24 hours). The average for all years is 10.2 storms per season lasting more than 24 hours. It would be very interesting to collect similar data for stations in Iowa and other good pheasant states. The comparatively high total number of storms recorded for these areas in Table 8 considered together with the high percentage of sunshine, compared to the figures for Rhode Island, indicates that the duration of cloudy (and wet) conditions following rain is considerably shorter than in Rhode Island

6. Temperature variations

The summary of the monthly mean values for maximum and minimum temperatures for eight stations will be found in Table 12. These values were computed for a period of 10 years, from 1945 through 1954 for Iowa, Nebraska and South Dakota, and from 1940

Table 12. Average monthly maximum and minimum temperatures for eight stations representing four states for May through August.

Average Minimum Temperature								
	Webster City, Iowa	Cedar Rapids, Iowa	Lincoln, Nebraska	North Platt, Nebraska	Huron, South Dakota	Rapid City, South Dakota	Kingston, Rhode Island	Providence Rhode Island
May	46.27	47.6	49.4	45.0	43.0	41.6	44.6	49.2
June	57.7	59.0	61.0	56.1	54.8	50.8	52.6	57.37
July	61.2	62.3	65.4	61.4	60.5	58.2	59.6	64.1
August	59.3	61.0	64.6	60.3	59.0	57.1	56.9	61.5

Average Maximum Temperature								
	Webster City, Iowa	Cedar Rapids, Iowa	Lincoln, Nebraska	North Platt, Nebraska	Huron, South Dakota	Rapid City, South Dakota	Kingston, Rhode Island	Providence Rhode Island
May	70.3	70.7	72.8	69.3	68.4	65.6	66.1	68.0
June	80.7	80.4	84.0	81.0	78.1	74.6	76.6	77.5
July	85.9	85.4	89.3	87.2	86.0	86.2	80.11	83.0
August	84.4	85.4	85.9	84.9	84.9	85.6	78.7	80.7

Averages for Iowa, Nebraska, and South Dakota calculated on 10 years (1945-1955).
Averages for Rhode Island calculated on 15 years (1940-1954).

through 1954 for Rhode Island.

Comparison of the stations does not show any striking differences in temperature averages between Rhode Island and the other three states. Temperatures on the whole, both maximum and minimum are somewhat cooler than those for Iowa, but no cooler than for South Dakota, except in the maximums for the last two months, where temperatures range from 2°F., (Providence), to 5°F., (Kingston), below the lowest South Dakota averages in July, and 4°F., (Providence), to 6°F., (Kingston), in August.

Months were also classified into the number of days where the maximum and minimum temperatures dropped below 32°, 40° and 50° (F.). The results, summarized in Table 13, follow the same pattern as the temperatures listed above, except that only Kingston shows a higher average number of cool nights in July and August.

7. Comparison of temperatures at three inches and five feet

The area inhabited by pheasant chicks during the first month of life is close to the ground. It has been known for some time that the micro-climate near the ground is greatly affected by the type and condition of both the substrate and the vegetation. This climate may be so modified as to be considerably different from that recorded at the standard five-foot weather station level, from which all of the preceding data was recorded. The actual amounts of rain and sunshine received will be the same, but temperature and humidity are easily affected by their surroundings and therefore will show

Table 13. Average days per month where temperatures equalled or fell below 32 degrees, 40 degrees, and 50 degrees F. for May through August.

		Webster City, Iowa *		Cedar Rapids, Iowa		Lincoln, Nebraska		North Platt, Nebraska	
		Maxi-mmum	Mini-mum	Maxi-mum	Mini-mum	Max-mum	Min-mum	Maxi-mum	Mini-mum
May	32 F.		1.6		1.2		0.6	0.1	2.1
	40 F.		8.1		6.4		4.2	0.9	7.8
	50 F.	1.2	21.2	0.4	20.0	0.9	15.2	1.4	25.5
June	32 F.								
	40 F.		0.6		0.2				0.6
	50 F.	0.1	5.9		4.9		2.6	0.5	5.8
July	32 F.								
	40 F.								0.2
	50 F.		1.8		1.1		0.1		1.4
August	32 F.								
	40 F.		0.3		0.2				
	50 F.		3.6		2.1		0.5		1.4

		Huron, South Dakota		Rapid City, South Dakota		Kingston, Rhode Island		Providence, Rhode Island	
		Max-mum	Min-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum
May	32 F.		3.9		3.2		1.9		
	40 F.	0.1	11.5	0.5	12.2		9.2		2.46
	50 F.	1.9	25.2	2.6	27.0	0.6	24.5	0.6	18.4
June	32 F.				0.2		0.1		
	40 F.		0.9		2.4		2.1		.1
	50 F.	0.2	5.2	0.9	13.9	0.2	10.4	.1	3. 8
July	32 F.								
	40 F.		0.1		0.1		0.1		
	50 F.		2.0		3.1		4.2		0. 3
August	32 F.		0						
	40 F.		0.4		0.1		0.6		
	50 F.		3.2		2.7	0.1	7.21		0. 9

* Average calculated from same years as figures in Table 12.

some variation (Geiger, 1950). Dr. Robert Wakefield's data were collected in the same general region as that taken in the Great Swamp, the stations being three miles apart, at the same altitude, and it has been assumed, that the weather conditions were similar in both areas. The slight differences in temperatures recorded at three-inches for the two stations (Table 14) could be the result of slight actual differences in the weather in the two areas or could more probably be due to the natural physical setting of the instruments. Dr. Wakefield's thermograph was placed over mown turf in an open unshaded area; the instrument used at the swamp was set in a slightly sheltered area over the uncultivated border of a hay field where plants were considerably taller. In the three months compared, average temperatures were always colder at night and warmer in the daytime for Dr. Wakefield's data with one exception: in June during the daytime the two averages are very close, that at the Great Swamp being slightly higher. Because air mixing will be retarded in a sheltered area with higher vegetation, temperature extremes will be reflected more slowly than in an open area, and the differences in the two sets of data seem reasonable.

Five-foot and three-inch temperature series collected by Dr. Wakefield are summarized and compared graphically (Figures 6-11) for April, May, June, July and August. An attempt to correlate the differences according to daily weather occurrences was unsuccessful. The graphs show clearly that in all months there actually is considerable variation of the three-inch from the five-foot temperatures. In April and the first

Table 14. Average maximum and minimum temperatures for July, August and September, 1955 recorded at the Great Swamp compared with data taken at the University of Rhode Island Experiment Station by Dr. Robert Wakefield.

	July		August		September	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Great Swamp	89.69°F.	66.46	82.37	62.18	69.65	51.22
Experiment Station	89.07	63.76	85.81	59.81	78.86	49.90

half of May these variations occur on either side of the five-foot line, with the modal class coinciding with the five-foot level. The bar graph (Figure 11) shows the distribution of deviations about the five-foot temperatures. The straight vertical bar represents the five-foot temperatures, the horizontal bars show the range of deviations in each month from the five-foot level; the modal class is indicated by the solid point on each bar, and the arrow indicates the average deviation. May apparently has two modal classes, and on Figure 7 a rather abrupt change in the deviations occurs near the middle of the month where practically all of the minimum three-inch temperatures occur below the five-foot ones, and all of the maximums above it. In other words, during the night, it is colder near the ground, and during the day it is warmer. This pattern is continued through the summer months. The mean difference in minimum temperatures ranges from 2.57° to 1.56° below the five-foot temperatures during these months. The validity of these observations in describing a trend is of course limited by the fact that data was available for only one year in this area. Data from other years would be essential for a proper examination of these phenomena.

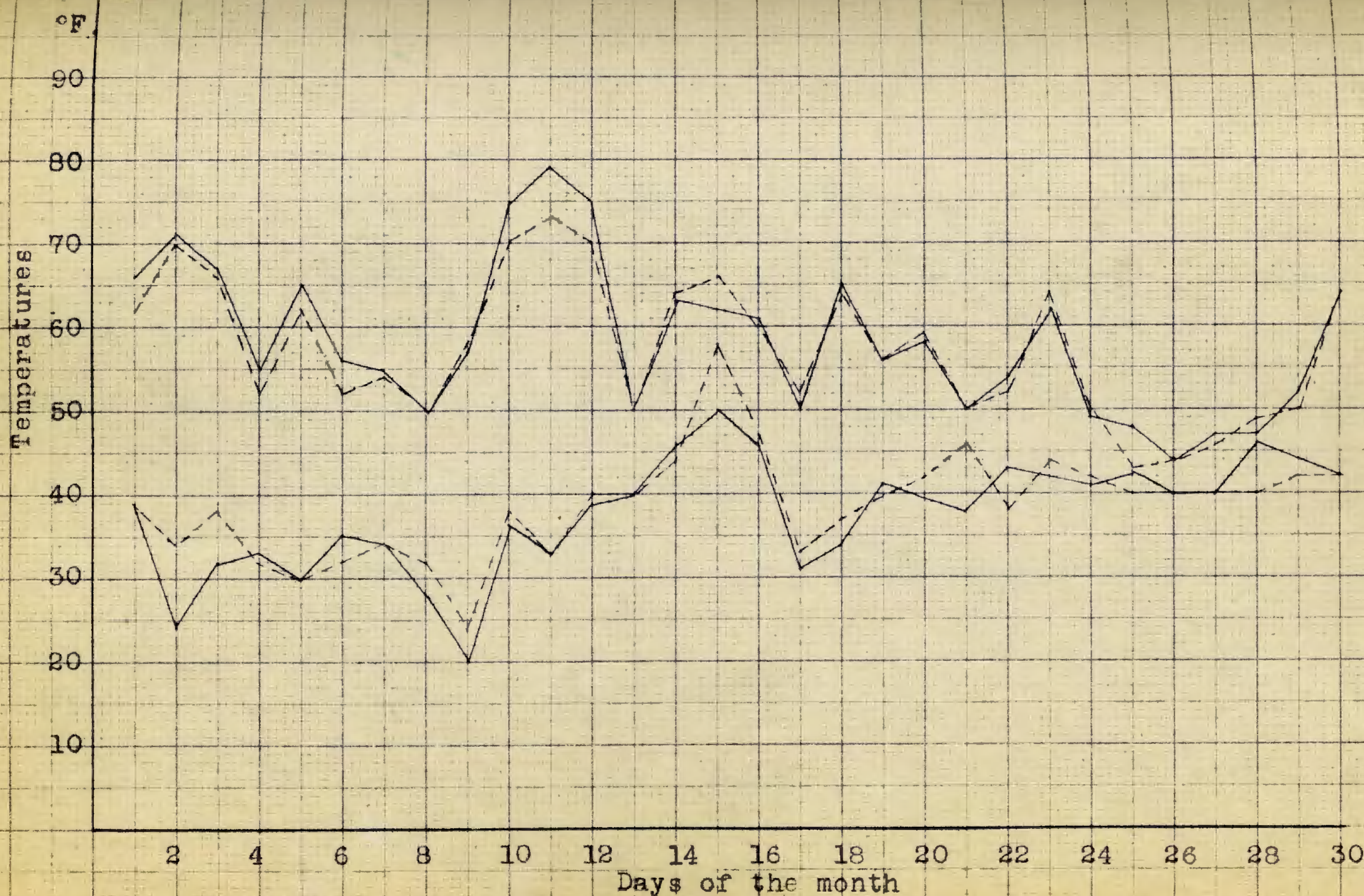

Figure 6. Maximum and minimum daily temperatures at five feet and three inches above the ground in April, 1955. Entire line represents five foot temperatures, broken line, three inch temperatures.

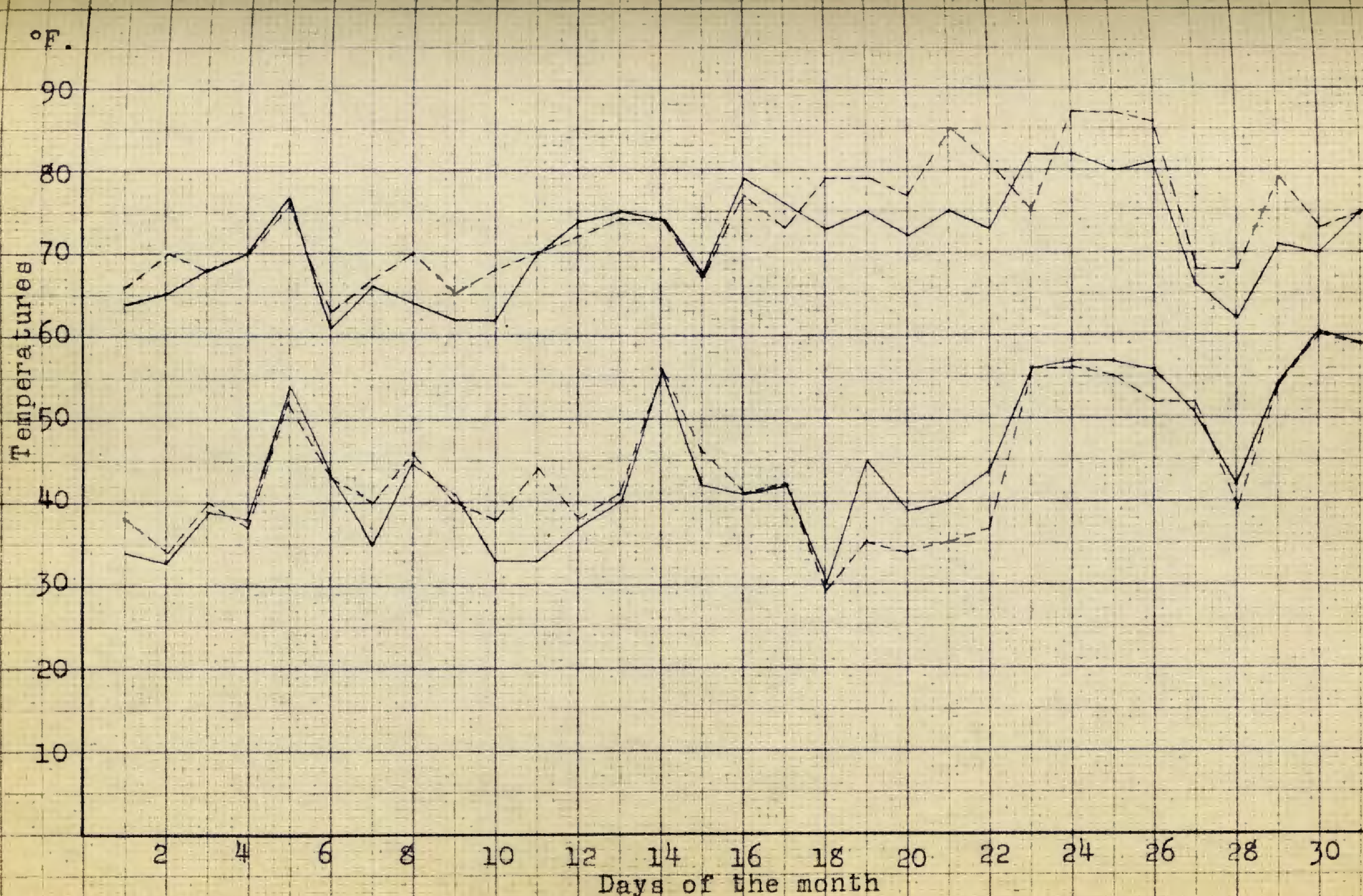

Figure 7. Maximum and minimum daily temperatures at five feet and three inches above the ground in May, 1955. Entire line represents five foot temperatures, broken line, three inch temperatures.

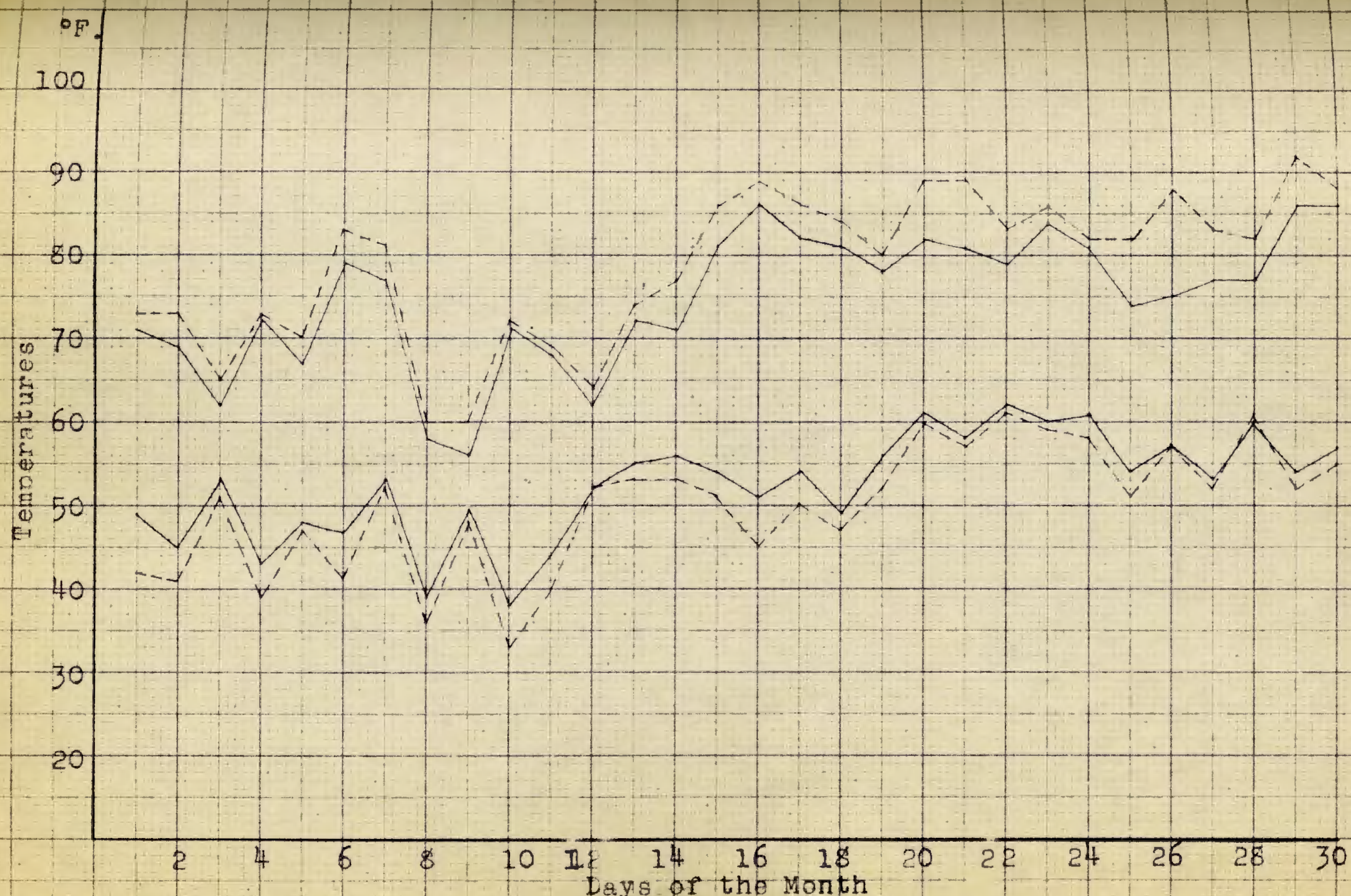

Figure 8. Maximum and minimum daily temperatures at five feet and three inches above the ground in June, 1955. Entire line represents five foot temperatures, broken line, three inch temperatures.

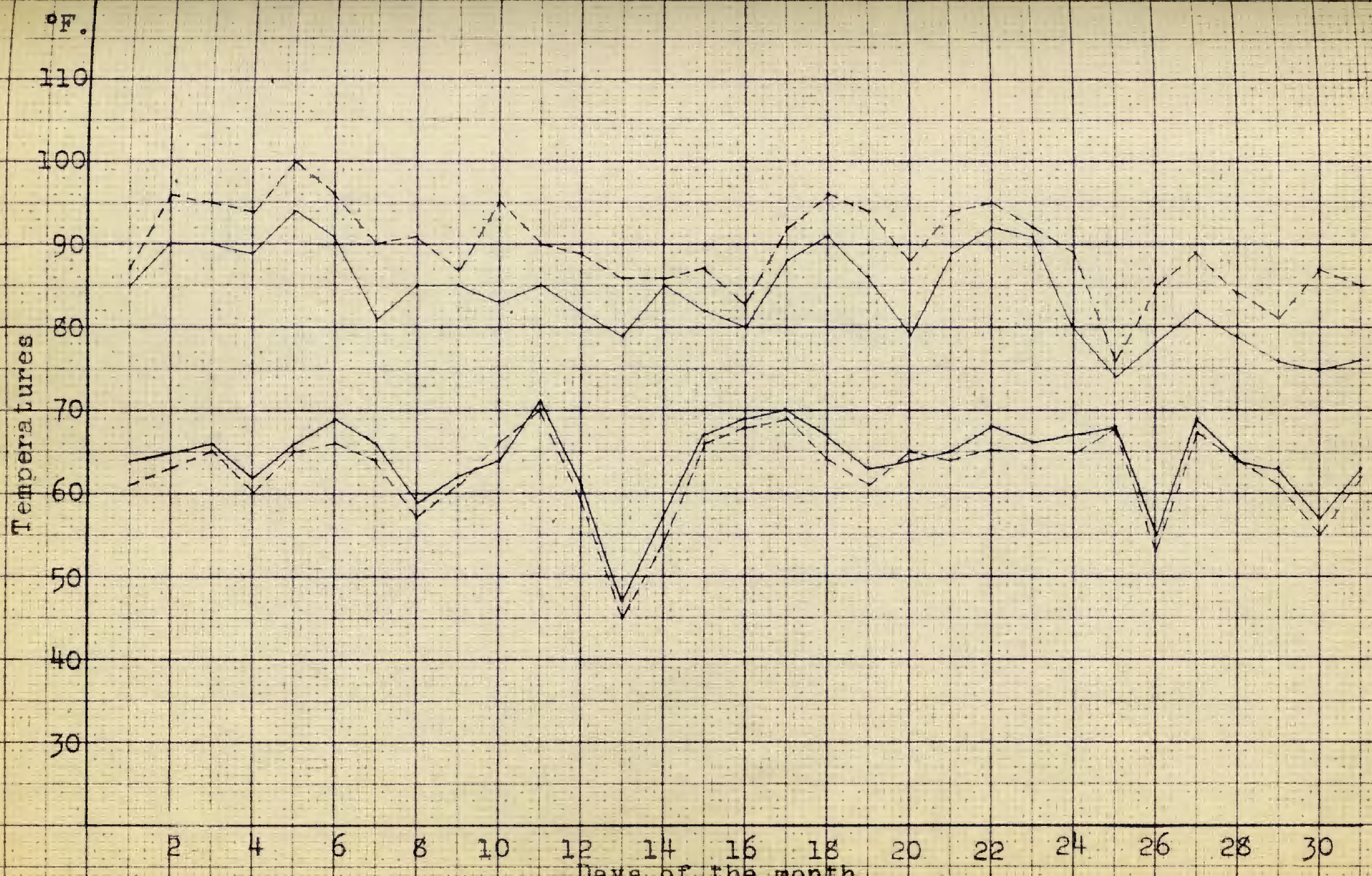

Figure 9. Maximum and minimum daily temperatures at five feet and three inches above the ground in July, 1955. Entire line represents five foot temperatures, broken line, three inch temperatures.

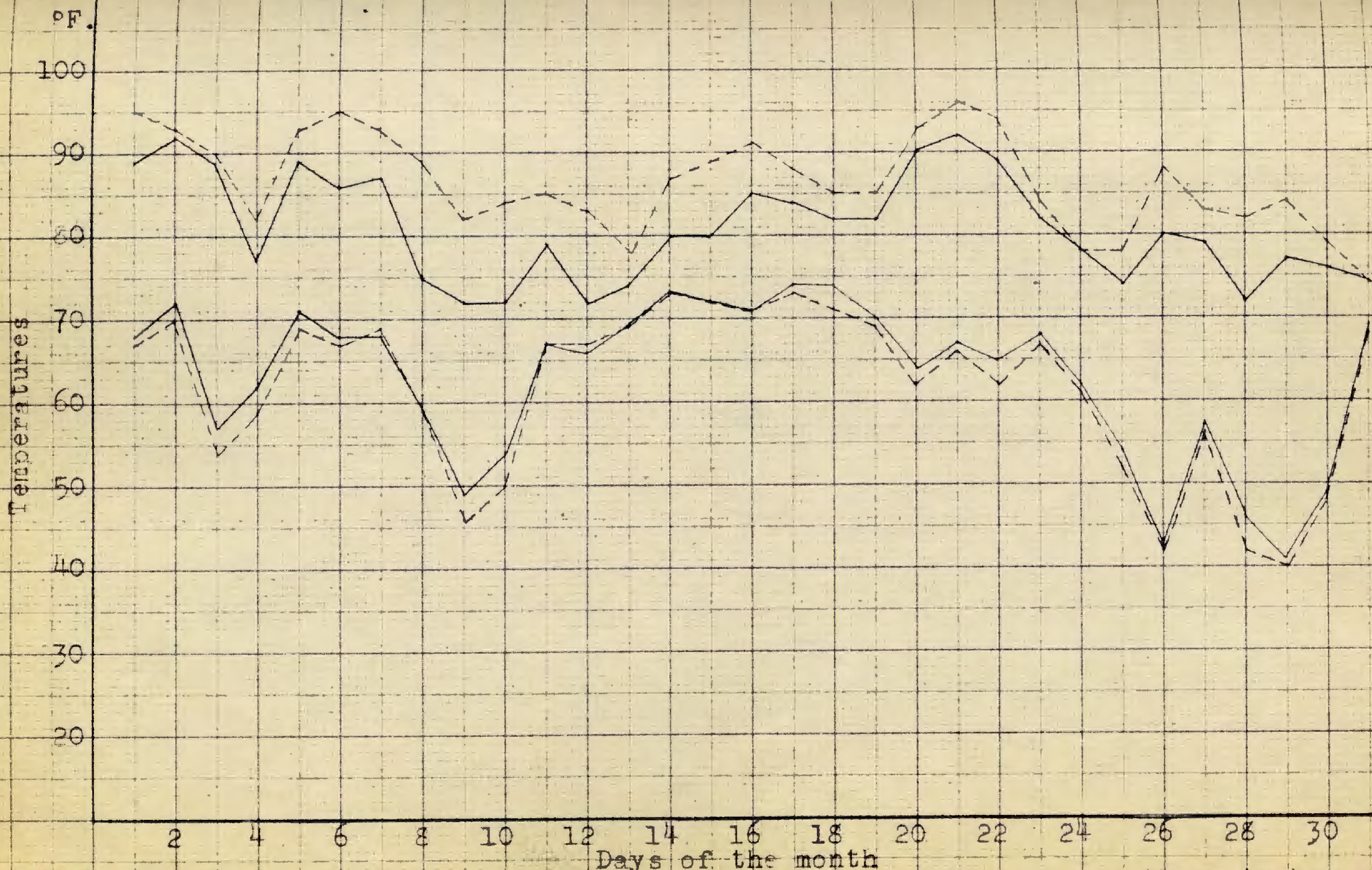

Figure 10. Maximum and minimum daily temperatures at five feet and three inches above the ground in August, 1955. Entire line represents five foot temperatures, broken line, three inch temperatures.

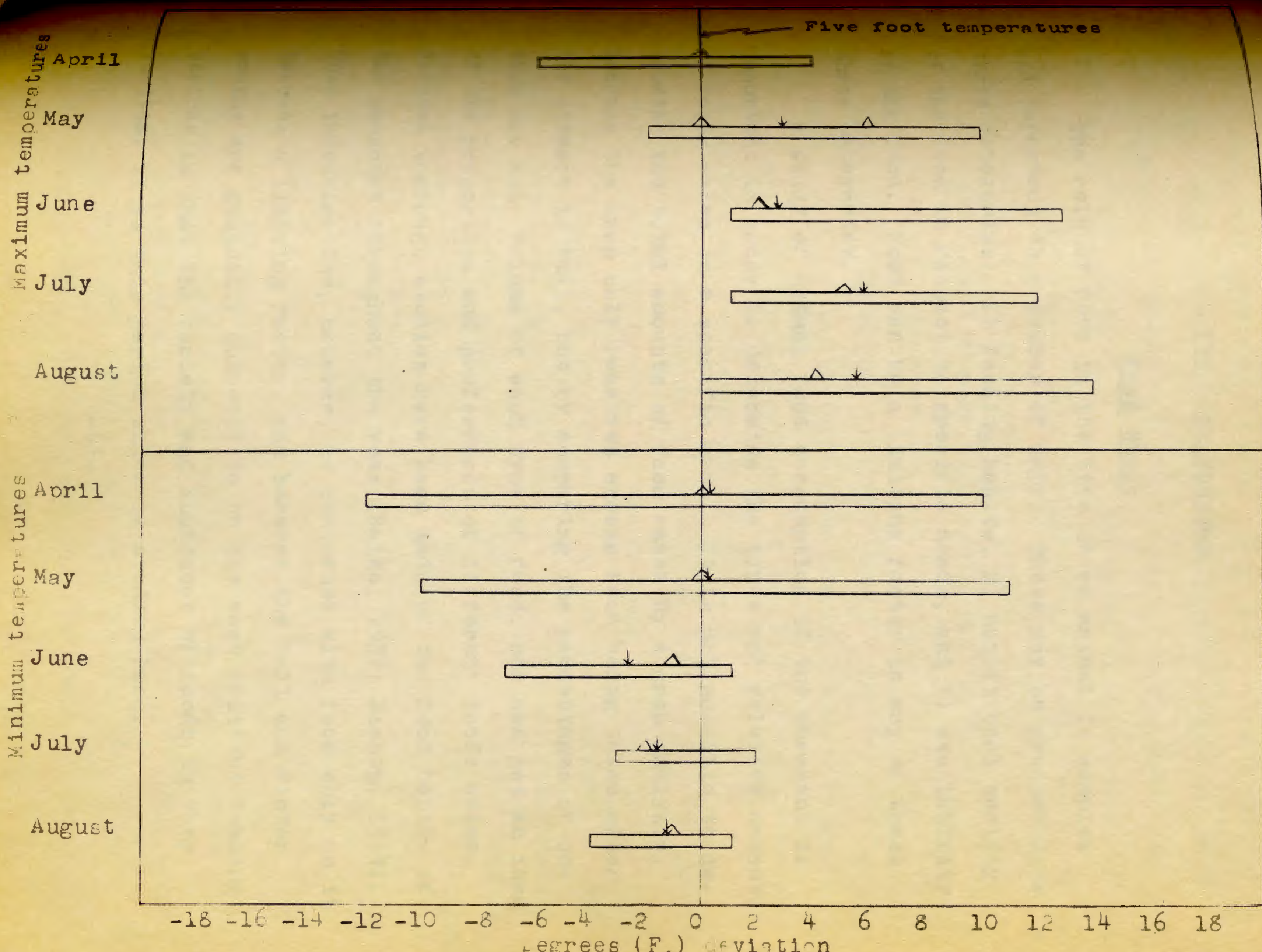

Figure 11. Deviations of three inch monthly maximum and minimum temperatures from five foot temperatures.

III. DISCUSSION

Food Study

The role of food in the life of an animal is complex and important in a number of ways. These may be grouped into three categories: 1) feeding habits, 2) nutritional quality of the food in respect to specific needs, and 3) availability of the food. Food can be a limiting factor in any of these three categories.

A study of actual food consumption of the pheasant is important in order to determine the types and relative amounts of foods eaten in a specific area. It is not possible to determine the total amounts of food eaten by a crop analysis, because the crop only receives excess food being taken after the stomach is full, but by comparing the percentages of occurrence and volume of each type of food, one can get an idea of the proportion and preferences of different foods eaten. Several thorough studies have been made of the food habits of the pheasant throughout the year (Dalke, 1937; Bishop, 1944). This investigation, however, is concerned with food only as it becomes a limiting factor, and because the fall and winter months are generally conceded to be the most critical feeding periods in that the variety and abundance of foods is very limited, it is this period which is studied here.

On page 24 it was stated that the crops from ten birds (out of 64) were completely empty. This does not necessarily mean that these ten birds were not feeding but only that they had not taken any excess food for at least several hours before death. Titus, in an unpublished study quoted by Nestler (Nestler, 1939), reports that in the barnyard fowl, digestion is very rapid, being completed one and one half to two hours after food has left the crop, and in 10 to 18 hours for a full meal. Both the pheasant and the domestic fowl are classified as gallinaceous birds, and similar digestive reactions may be expected. Further, normal feeding habits may have been somewhat disturbed by hunting pressure at the time since all crops were collected during the hunting season.

The data presented in Table 16 show that cultivated grains make up a very large portion of the average diet of Rhode Island pheasants. The figure of 85% grain of the total volume of food eaten compares favorably with studies made in different parts of the country (Table 17) with the exception of observations in Utah (Cottam, 1929) and a previous study in Rhode Island (Wright, 1940). The difference between Wright's data and the material analyzed in this paper might be explained by the fact that bayberries formed approximately 21% of the total weight of food taken in his study, while they composed only about 4% in this investigation. Bayberries occurred in 50% of the 16 crops examined by Wright and only about 5% (three crops) of those considered in this work. The month before hunting season two severe rain storms passed over Rhode Island, and in a trip

Table 16. Comparative percentages of fall foods taken by swamp pheasants, wild pheasants, and all pheasants sampled in Rhode Island, 1955.

	Percentage of Occurrence			Percentage of Volume		
	Total	Swamp birds	Wild birds	Total	Swamp birds	Wild birds
Cultivated grains	42.6	56.7	27.1	81.1	87.5	48.4
Wild seeds	21.3	13.6	27.1	0.7	0.9	1.6
Grass and Leaves	21.6	22.7	18.8	2.9	3.5	4.7
Fruits and Nuts	5.8	4.6	16.6	5.6	1.0	22.1
Animal matter	5.8	6.8	2.1	1.8	T*	T
Total cultivated plants	45.9	61.4	27.1	89.0	94.6	48.4

*Trace

through the Swamp two days later, not even a handful of bayberries could be collected from branches heavily laden before the storms. This probably explains the lack of bayberries in the crops of the birds considered in this study. The only three crops containing them had come from Patience Island, in Narragansett Bay, an area which may have been hit less severely by the storms.

The percentage of weed seeds found in this investigation is considerably lower than the amounts reported by all other studies cited in Table 17, including the previous study made in Rhode Island by Wright (Wright, 1940). The plant species other than cultivated plants that occur more than once are pigweed, snap weed, bayberry, shadbush, water smartweed and poison ivy. Many of these as well as the less commonly occurring species were also found by Wright. Wright also found several species occurring in abundance that were not found in this study, namely arrow-wood (Viburnum dentatum), skunk cabbage (Symplocarpus foetidus), rose grape (Vitis sp.), wild radish (Raphanus Raphanistrum), and milkweed (Asclepias sp.). Allen (Allen, 1953) and Trippensee (Trippensee, 1948) in their summaries of preferred wild foods list most of the ones found in this study as commonly occurring in pheasant diets; of the species found in this study, ragweed, snapweed, Polygonum spp., the nightshades, and wild cherry seemed to occur widely and in the largest amounts in Allen's and Trippensee's accounts.

The percentage of fruits and nuts, about 5%, is approximately the same as that found in other similar studies. The

Table 17. Comparison of percentages of pheasant foods determined in various studies in the United States.

Station	R.I.	R.I.	R.I.	Mich.	South Dakota	Nebr.	Utah	Pac. N.W.	R.I.	Estimate of whole country
Author (Date)	Anderson 1955 total birds	Anderson 1955 wild birds	Anderson 1955 great swamp birds	Dalke 1937	Trautman 1952	Swenk 1930	Cottam* 1929	Leffingwell 1931	Wright 1940	Wright 1940
Cultured grains	81.13	48.40	87.50	73.87	81.7	78.0	36.7	75.7	36.85	75
Wild seeds	0.68	1.55	.92	12.12	7.1	6.0	9.5	23.7	15.13	7
Grass and leaves	2.86	4.69	3.51	3.24	4.5				.299	-
Fruit and nuts	(1.33) 5.60	22.09 (4.49)	.98	7.48	---	---	5.5	---	41.49 (20.48)	6
Animal matter	1.80	T	T	3.24	5.4	11.0	14.5	0.1	3.38	7

*Quoted by Nestler, 1939.

percentage of grass and leaves with a volume of about 5%, also agrees with the figures from the other studies cited in this report.

In comparing the contents of the crops of birds from the Great Swamp with those of the remainder of the birds sampled, the percentages of different types of foods are approximately the same with the exception that the swamp birds eat a slightly higher amount of grains and cultivated plants, perhaps because of the relative abundance of these two items.

Wild birds show some differences in food habits from the stocked birds. Cultivated grains, while still making up the major food element by volume, compose only about half of the total volume eaten compared with almost 90% eaten by the Swamp birds. While 10 of the 16 wild birds had eaten cultivated grains, these grains composed only about one-quarter of the total occurrences of foods. Wild birds ate a somewhat larger volume of wild weeds than the swamp birds, and percentage occurrence in this group equals that of grain. A much larger variety of species also was eaten by wild birds (Table 4). A larger volume of fruits and nuts occurred in their crops than in the crops of the swamp birds, though most of this total volume is composed of the bayberries taken by the three Patience Island birds. The figures in parentheses in Table 17 show the percentage of fruits and nuts without bayberries. Another reason why the crops of stocked birds may not have contained bayberries or more species of wild seeds and fruits may be because these foods are unfamiliar, and consequently less attractive.

An adequate diet must supply at least sufficient amounts of the basic nutrients for an animal to perform all the required activities for the survival of the species. These activities include growth, reproduction and successful competition with other species in or near the same ecological niche. Ewing (Ewing, 1941) stresses the importance of a good diet for laying hens, because it seems to affect radically the survival and vigor of the chicks. In this sense, the term "food" includes not only fats, proteins and carbohydrates but also minerals, water and vitamins.

The above statements may seem obvious; nevertheless, the exact nature of the minimum nutritional requirements is often the last aspect studied about an animal. It is only in the past 25 years that any nutritional studies have been made of the pheasant, although much work in this field has been done on the related domestic chicken.

There seems to be very little in the literature concerning the fat and carbohydrate needs of the pheasant. Because it feeds primarily on grains and seeds which have a relatively high content of both these essential nutrient, it probably has been assumed that they are adequately supplied.

While no work on the protein requirements of adult pheasants was found, several studies have been conducted for chicks. Callenbach and Heller (quoted by Nestler, 1939) in some of the first work on this subject (in 1933) determined that during early growth, a pheasant chick needs about 28% protein in the diet. Norris, et. al., (Norris, Elmore, Ruywose and Bump, 1935) ran a series of tests which indicated that a 30% level of protein was necessary for maximum growth, and 21 to 24% for satisfactory growth. In his chemical analysis of the fall foods of the pheasant in Rhode Island, Wright (Wright, 1940, Table 5) concluded that plants of woody origin had a lower protein content than the domestic grains, while weeds of cultivation had a slightly higher one. Wright found a protein level of 12.9% in the fall pheasant diet in Rhode Island. He concludes that, "the approximate chemical composition of the total food of the ringnecked pheasant is below the accepted requirements of birds held in captivity" (page 42). In summarizing food studies made in other parts of the United States, Wright (op. cit.) found an approximate level of 15% protein. The difference between this figure and the one for his data perhaps exists because of the higher proportion of cultivated grains in other studies and a possible higher proportion of low protein seeds and fruits included in his. Although the food study conducted for this investigation was expressed in terms of volume, and Wright's was measured in dry weight, a very rough comparison can be made between gross amounts in both investigations. Twenty-one percent of the total food found in the crops examined by Wright was composed of low protein bayberry. Probably because of the relative lack of bayberry, the results of the present study would show a closer resemblance to the other protein analysis with the higher protein level. In a normal bayberry year (as previously explained) Wright's results are probably closer to the feeding habits for wild Rhode Island pheasants, and the lower protein level in his investigation may have a sufficiently detrimental effect upon the health of birds to decrease their survival possibilities during the rigors of winter. In addition it may affect the number and viability of eggs laid in the spring.

Enough preliminary work has been done to show that the vitamins A, D, E and riboflavin are as important to normal pheasant growth and reproduction as they are to human growth and reproduction. (See Ewing, 1941, and Nestler, 1939, for good summaries of the literature on this subject.) The whole grains as a rule are rich in these vitamins, a particularly important point because further work may show them to constitute limiting factors in the diet of wild birds. No vitamin analyses were found for the common wild foods of the pheasant, and none were attempted by this investigation because it was considered that such work was beyond the scope of the present study.

Allan (Allan, 1953) reports that a study in Michigan showed that pheasants can exist on only dew as a source of water. It would appear from this Michigan study that a lack of water generally is no problem where much occurs as dew. Even if a watering place were needed, there are numerous springs within the Great Swamp Reservation. Consultation of a topographical map reveals the presence of many small marshy areas, streams and ponds in southern Rhode Island, so that the presence of drinking water is probably not a limiting factor here.

Some work has been done to show that the minerals calcium, phosphorous and manganese are extremely important in the diet of the ringneck. Leopold (Leopold 1931) first posed the question of a calcium deficiency as a limiting factor in discussing the distribution of the pheasant with his "glaciation hypothesis." In a study of the ringneck pheasant in the north central states he discovered this significant fact. In two identically appearing, even adjacent areas, one had a high pheasant population, the other none at all. The only apparent difference between such areas was that the productive one was glaciated, the unproductive one unglaciated. With a very few exceptions, he found this distribution-glaciation relationship held true for the whole state of Iowa. His observations were substantiated by a more careful study (then unpublished) by Hicks and McCormic in Ohio. The fact that New England is well glaciated and does not produce large populations of pheasants seems to disprove the hypothesis. Leopold was the first to point out this discrepancy and suggested that the source of the difference in glaciated areas lay in some factor brought into the soils of the region by the glacier, perhaps lime. The elements that a glacier brings into an area depend on the composition of the rock north of the area.

Leopold's suggestion was considered recently by three workers, Derby, DeWitt and Dale at the Pawtuxant Wildlife Research Laboratory in Maryland. They investigated the importance of calcium in the survival and reproduction of the pheasant with special reference to geographical distribution in the United States. Dale states (Dale. 1954) that in an unpublished report, DeWitt and Derby established the fact that 0.5% calcium in the pheasant's diet is the minimum for successful reproduction. Fed on a grain diet, pheasants need about 250 milligram of calcium per day. Vitamin D, phosphouous and protein constituents in the diet affect the absorbtion and utilization of calcium. The above figure is the minimum calcium need to balance the other nutrients in the grain diet. It has been shown that a large part of the diet of the pheasant is grain, and therefore this figure can stand at least approximately, for the average calcium needs of the pheasant. Ewing (Ewing, 1941) has estimated the calcium content of the following groups of common pheasant foods:

Cultivated grains	0.05%
Wild seeds, fruits, nuts	0.5 %
Grass and Leaves	1.0 %
Animal matter	2.0 %

Using these estimates, Dale (Dale, 1954) calculated the probable calcium of two food studies of birds in Michigan (Dalke, 1937) and South Dakota (Trautman, 1952)(Table 17). The calcium of the entire diet in these studies was found to be 0.227% and 0.229% respectively (Dale, 1954, page 318). Dale therefore feels that while the pheasant probably has no higher requirement for calcium than other gallinaceous birds, it is more likely to be calcium deficient because a high percentage of the foods preferred and eaten by the bird is low in calcium. The inclusion of limestone grit is apparently very important. In areas where calcium is high in surface soils the birds may get enough either by ingesting the soil itself or by eating foods which have a large luxury consumption of calcium. He compares Walworth County (South Dakota) soil, containing 2.29% calcium, a highly productive area, with Cecil loam from Maryland, a poor productive area, having a calcium content of 0.05%. Whether this is total calcium or "available" calcium he does not say; it is probably the available type. Dale demonstrated experimentally that penned pheasants fed on a diet comparable to that found for pheasants in productive areas failed to produce a normal quota of eggs, and hatchability of the few that were produced was similarly low. When a calcium suppliment (representing the limestone grit that would be picked up by wild pheasants) was added to the diet, these conditions were corrected. This work is very significant in demonstrating conclusively that the occurrence and availability of calcium may be one of the limiting factors in successful pheasant reproduction in some regions. The glaciated areas examined by Leopold contained much limestone grit, and this seems in part to substantiate his thoery.

An attempt was made to determine what percentage of calcium was found in Rhode Island soils and how much, if any, calcium-bearing grit was to be found in them. In a personal interview with Dr. Milton Salomon of the University of Rhode Island Experiment Station, Dr. Salomon stated that in his opinion the amount of calcium available to plants in uncultivated soils in Rhode Island ranged from 0.02% to 0.04%, and is probably closer to the former figure.

No known studies have been made of the mineral composition of the glacial gravels of the state. An effort was made to consider the types of rock that were brought into the area by the glaciers. These rocks should be composed of the same minerals as any gravels present. In a bulletin of Rhode Island soil types by Smith and Gilbert (Smith and Gilbert, 1945) the following parent rocks are listed as being the major soil precursers:

1. Granite, composed of quartz feldspar, mica, hornblend and "accessory minerals;"
2. Granite gneiss;
3. Mica schist;
4. Sedimentary rocks; and
5 Other rocks: igneous diorite in the northwest portion, an outcropping of magnesic limestone in the northeast section, graphitic coal about Narragansett Basin, and quartz in the northern area.

In the ground water survey of Rhode Island for the Georgiaville quadrangle (Richmond, 1951) it is stated that the gravel over most of the quadrangle contains about one-percent rotted cobbles and pebbles that are composed mostly of biotite schist, diorite, basalt granite and gneiss. Professor Clarence E. Miller of the University of Rhode Island Geology

Department explained that only such "rotted" material would be usable as a calcium source by the pheasants, since the parent rocks were relatively insoluble forms of calcium. He stated that gravels in this part of southern Rhode Island would be of a similar composition because they came from the Georgiaville region. Of these minerals the chief calcium-bearing ones with their percentages of calcium are listed below:

Hornblend	10 - 13%
Diorite group:	
Plagioclase	up to 17%
Epidote	22 - 23%

These minerals seem to be of fairly common occurrence in the rocks found on mineral maps of Rhode Island. The question of why calcium is not more available may be due to two factors: (1) In the unweathered state, the calcium-bearing minerals are very insoluble and (2) the relatively high acidity of most of Rhode Island's soils (average pH of 4) helps to keep these minerals in an insoluble state. Smith and Gilbert (<u>op. cit.</u>) also have this to say about the decomposing calcium and potassium rocks: "In Rhode Island profiles, those elements are readily removed by leaching, leaving the soils relatively deficient, despite granitic origin" (page 7).

It was felt desirable to know more about the actual composition of the gravels in southern Rhode Island soils. Samples were taken from areas of Gloucester and Narragansett soils in and near the Great Swamp Reservation both common and widely distributed soil types in southern Rhode Island. Examination of the gravels from the samples failed to show any appreciable quantities of calcium-bearing minerals, the only ones occurring being chlorite and a carboniferous schist, both in trace amounts. The procedure used was admittedly a rough one, and the number of samples too small to draw any definite conclusions. This preliminary sampling does show, however, that there is a possibility that there is an absence of calcium-bearing grit in Rhode Island soils and that this fact may have a limiting effect on local pheasant populations. It gives very strong indications that a more thorough study of the local soils should be undertaken.

There are several factors which affect the availability of food. First, the proper foods must actually be present in the environment in sufficient quantity. Second, the pheasant must be able to get at these foods at all times, which means that the foods must be (a) within reach, (b) not covered at critical periods with ice or snow, and (c) in a form usable to the pheasant. To illustrate the last point, seeds such as acorns, enclosed in a hard thick shell, to be utilized by pheasants, must first be opened, perhaps in this case, by a rodent.

Competition with other animals is another factor involved in the availability of a food. The cultivated grains such as corn, which constitute a large percentage of pheasant food, are also eaten by other birds, deer and rodents. Where these grains form almost the sole winter food supply, high populations of these competitors might influence the number of pheasants a range could support during critical feeding times. Grain on or near the ground disappears especially rapidly, and of course is covered during periods of deep snow in the winter. It is necessary, if the food is to be available all winter, that some of it must remain standing. In the case of harvestable grains, it would be desirable either to leave some uncut or standing in shocks in the fields. Allen (Allen, 1953) has pointed out that the type of harvesting practiced during the war in certain areas in the United States was certainly one of the factors contributing to lower populations of pheasants at that time. Along with the clear harvesting came the destruction of hedgerows, which had provided both nesting sites and sources of wild winter foods. Only a small part of the grains grown in the Great Swamp is harvested annually, the intention being to leave standing grain for winter feeding. The hurricanes of the fall of 1954 flattened most of the fields that year, and the fall swarm of hunters in the Great Swamp trample the fields well in other years. Thus almost no grain remains standing. Observations found very little grain on the ground for the winter of 1954-55. An examination of the food patches in the early spring of 1956 revealed only a few seeds remaining in most of the millet heads found on the ground.

No actual census was attempted for food competitors in the swamp. After snow falls, each food patch yielded a plentiful supply of mouse, chipmunk, squirrel and deer tracks. There is no scarcity of these and additional competitors for grain in the Great Swamp. Nothing could be found in the literature concerning the effect of food competitors on a pheasant population. Here is an additional important problem for future study.

Because extended periods of snow cover are rare in Rhode Island, it is probable that any foods present remain available throughout the winter. Dalke (Dalke, 1943) reports observing pheasants pecking through as much as an inch of ice to get at standing corn, and feels that ice, therefore, is not a factor in Michigan. It is probably not a limiting factor here also. Even during extensive ice or snow cover, a number of studies have shown that the pheasant can exist for periods up to a month on emergency foods low in nutritious value, such as sumac, Russian olive, black locust and burdock (Swanson, 1952, Throckmorton, 1952).

In order to see what foods were available in southern Rhode Island in any quantity during the fall and winter months, a vegetation survey was taken. As pointed out previously, the lists compiled are by no means intended to be a complete listing of all the species in the area but only an account of those plants which appear as dominants in the vegetation community at the time. Viewed in this way, the lists represent a reservoir of possible foods during critical times.

Contrasting these lists with Table 2, aside from cultivated plants, there are only eight species that occur on both: bayberry, alder, poison ivy, oak, boneset, wild black cherry, red maple and goldenrod. These eight species account for 12 out of 156 occurrences, and 24 milliliters out of a total volume of 476.64 milliliters. Bayberry accounts for three occurrences and 20.27 milliliters and a whole unshelled (unusable) acorn for 1.70 milliliters, leaving 2.03 milliliters, or less than one-half of one percent of the total food taken occurring as dominants on the survey lists. Of these, only cherry, poison ivy, alder, red maple and goldenrod are found in large numbers. The amounts of weeds of cultivation commonly found in this region were unintentionally omitted from the lists. A study of those found in cornfields in Connecticut (Bishop, 1946) shows that the most common ones are ragweed, Ambrosia artemisiifolia, lamb's quarters, Chenopodium album, smartweed Polygonum pennsylvanicum, barnyard grass, Echinochloa cris-galli, pigweed, Amaranthus retroflexus, yellow foxtail, Setaria glauca, witch grass, Panicum capillare, and crab grass, Digitaria sanguinalis. Of these, ragweed, lamb's quarters, pigweed and the smartweeds are represented in the fall foods of the pheasant, making up 15 out of 158 occurrences, and 2.79 milliliters, or 0.61% of the total volume. Of 27 wild foods, only seven were eaten more than once, all except snapweed occurring either on both lists or on the cultivated weed list above. It appears that there is not a very great correlation between the plant species found in abundance during the fall and winter in the Great Swamp and the wild species eaten at these times by the pheasants. Perhaps this explains the very low volumes of wild seeds found in the crops. Wright (Wright, 1940) found that many of the wild seeds (except bayberry) taken by pheasants were high in nutritious value but it appears from this study that these same seeds were too few on the uncultivated lands in the swamp to contribute much to the support of a large pheasant population. No checks were taken on other uncultivated areas in southern Rhode Island, but the history, climate and soil types found in the Great Swamp are the same as those those observed elsewhere in this general area, and it is probable that vegetation is similar also.

Because the uncultivated areas do not seem to produce large quantities of winter foods, the diet of any pheasant population that is maintained in southern Rhode Island must be composed principally of foods produced in cultivated areas. Tables 2, 3 and 4 show that this is the case, and that of the cultivated foods utilized, the grains make up by far the greatest volume. The census of agriculture (United States Census of Agriculture, 1952) shows that in Rhode Island in 1949, out of a total land area of approximately 577,120 acres, 6,139 acres were harvested in corn and 1,736 in small grains, making a total of 7,515 acres of cultivated grains, or 1.32% of the land area; Washington County (which includes southern Rhode Island) has a total area of 207,360 acres, and produced 1,059 acres of corn and 647 acres of small grains that year, a total of 1,076 acres, or 0.51% of the land area. It is a well known ecological principle that the natural population on a range will be only as large as the range can sustain. If winter food is a limiting factor of the pheasant population in this area, and it appears that it is, then if a larger wild population is to be maintained, a larger winter food supply will have to be provided. This can be done by encouraging the desirable wild foods to greater abundance on uncultivated areas, and by putting more acreage into cultivated grains, some of these remaining unharvested specifically for the fall and winter food supply of pheasants. This then becomes a question of farming economics, a problem far too extensive for this investigation.

B. Weather Study

The effect of climate on the survival of an animal is sometimes more difficult to determine than that of food. Whether it affects the animal directly as in the case of freezing or indirectly such as affecting the food supply, it is probably a major limiting factor for even so adaptable an animal as the ringneck pheasant. The spectacular decline in pheasant populations in this country in the third and fourth decades of the twentieth century caused a great deal of comment and study. At first the predators were blamed for this decline, but subsequent studies (Allen, 1953, Trippensee, 1948, Scott and Willard, 1955, Benson, Mason and Robeson, 1955) indicated that this was not likely. The reduced pheasant populations were than correlated with the occurrance of cold wet springs (Allen, 1953). Some flooding of nests had been observed but otherwise no data were found which dealt with the possible specific effects of unfavorable weather.

The bulk of the pheasant crop harvested each year is composed of the young adults produced that season. By knowing (a) the ratio of hens per cock in an area, and (b) the average number of a clutch surviving up to the hunting season under favorable conditions, it becomes possible, by examining the ratio of young to old pheasants killed, to estimate the nesting success in any one year. Kimball (Kimball, 1956) estimated that in a favorable year one would expect to find five or six young hens (in this case hens were also being shot without limit) per old hen, and in a poorer year, three or four young per old hen. He found in 1945, in the fall preceding the two years of pheasant decline in South Dakota, a ratio of only one young hen to one adult. This means that there was a smaller than normal breeding population for 1946, the following year, and indicates that the decrease in population was probably due to some factor acting upon a year class in its first season. The cold wet springs were found to be the unusual factor occurring in this prime pheasant country. Graham and Hesterberg (Graham and Hesterberg, 1948) constructed climographs of four areas of high pheasant population having diverse climates. They found that these four areas were alike only in the months of April, May, and June, the critical hatching and developmental months. The adult birds survived the extremes of weather found during the rest of the year. These two studies indicate that if weather conditions were a factor in the survival of a year class, the critical period must have occurred during the stages from nesting through hatching and early development. Both of these studies were made in parts of the country where normally, ideal habitat conditions exist. In order to determine whether climate might be a factor here, comparisons were made of a number of the aspects of weather during the late spring and summer months in southern Rhode Island with those in known excellent pheasant country in order to determine whether there were any important differences. These differences were then considered to find out whether they might have any effect on egg or chick survival.

No major differences were found in temperature or in actual amounts of rainfall. The central states had considerably more days of total rainfall while Rhode Island recorded slightly more days measurable rainfall in July. Rhode Island showed an interesting combination of these two aspects; while Iowa is as wet as Rhode Island, it is warmer; Nebraska is as cold as New England, but drier. New England is both cold and wet. In addition, Rhode Island has less sunshine, fewer total clear days and more totally cloudy days than any of the central states. From this it seems reasonable to suppose that Rhode Island has storms of longer duration than do the states of high pheasant density.

One of the most complete investigations of the effect of low temperatures on the survival of pheasant eggs was made by MacMullan and Eberhardt (MacMullan and Eberhardt, 1953), whose results are presented in Table 18. Eggs exposed to temperatures even as low as 45°F. for 16 hours had a survival rate of 85% up to 16 days of age. After this age, the amount of exposure tolerated without excessive mortality dropped to 16 hours at 55°F. for 16-day eggs or 16 hours at 65°F. for 22-day eggs. Two-day eggs survived 48 hours of exposure at 45°F. with a rate of 71%, and 4-day eggs survived 36 hours of exposure at 45°F. at 67%. Eggs apparantly became more susceptable as they got older. Of 22-day eggs tested with below freezing temperatures, 72% survived for five hours, but only 25% survived for six hours. A series of alternate heating and cooling of 16-day eggs was included in this experiment in an attempt to evaluate possible losses that might occur with the hen feeding normally. The eggs were alternately chilled for two hours at 45°F. and warmed for four hours, for a total of 14 hours of chilling. No significant mortality was observed.

Translated into terms of field conditions, the above results indicate that during May, when laying reaches a peak and most of the eggs are in the first stages of incubation, they are not very vulnerable to long periods of low temperatures. In June, when the eggs are in their last stages of development or are hatching, vulnerability to dropping temperatures increases. The danger of chilling to eggs exists in the day time, since the hen presumably stays on the nest, and would be driven off only temporarily during a very heavy down-

Table 18. Percentage Survived of Incubating Pheasant Eggs Exposed to Lowered Temperature

Temperature of Exposure	Hours of Exposure	Days of Incubation 2	4	6	8	10	14	16	22
68-62°F.	30					91	100	100	
	48					86	94	23	
	60					90	50	7	
65°F.	8	80	90			75		80	85
	16	89	80			80		95	85
	24	90	70			72		72	60
[illegible]5°F.	8	80	80			75		90	65
	16	70	85			100		80	45
	24	90	77			70		13	5
[illegible]5°F.	8	73	76			100		85	80
	10								21
	12								11
	16	77	60			85		0	0
	24		55			8		0	0
	30	74	67	0	0				
	36	71	67	0	0				
	48	71	7	0	0				
[illegible]2°F.	1								90
	2								100
	3								89
	4								80
	5								70
	6								25
	7								20

pour at night. At this time a high mortality would be expected if the hen were absent from the nest for five or six hours when the temperature fell below freezing, or for more than 16 hours with the temperature at 65°F. Unless the hen abandons the nest completely, it is not likely that she would be absent for such a long time. The weather data reveal that daily temperatures in June fall below 50°F. on the average of less than one day per month at the coldest station considered, Rapid City, South Dakota, and only 0.2 days per month at Kingston. If the mortality of eggs, because of exposure to low temperatures, were significant in terms of population size, it would surely be greater in South Dakota than here. This is not the case, and it can be concluded that such is not the case here either. MacMullan and Eberhardt (op. cit.) also performed tests on the survival of 16-day eggs exposed to simulated rain and concluded that 10 to 12 hours of rain at temperatures below 72°F. might cause significant losses. As indicated before, the hen is usually not off the eggs as long as 10 or 12 hours, and it is unlikely that rain is often a cause of extensive mortality of eggs.

It is common knowledge amoung game breeders that pheasant chicks are extremely vulnerable to wetting until the time when they become fully feathered, at about six weeks of age. Even during the warm summer rains, excessive mortality is likely to result unless the chicks are herded into shelter and confined there during the period of rainfall or, if wetted, are not dried immediately. It would seem from the above evidence that the shelter provided to the chicks by the hen under field conditions is extremely important in their survival.

In spite of all the accumulated observations, very few laboratory or field experiments have been done to determine the effects of specific weather conditions on pheasant chicks. In the egg research MacMullan and Eberhardt also performed a very limited experiment on the effect of low temperatures on chicks. At a temperature of 45°F., four chicks were exposed for 15 minutes and all of them survived. After one hour's exposure, three out of four chicks had survived. Nine chicks were exposed for three hours, with none surviving. MacMullan and Eberhardt conclude that "while the experiment with chicks was limited it suggested that chicks are highly dependant upon the brooding hen for warmth. Conceivably, cold, especially in conjunction with precipitation could cause wide-spread mortality if it occurred at a time when a large proportion of the chick population was vulnerable" (MacMullan and Eberhardt, 1951, page 330).

Roger M. Latham (Latham, 1947) did a very interesting series of experiments on the survival of chicks at various ages under differing weather conditions in an attempt to compare the survival ability of male and female birds. His results are presented in Table 19. All of the animals were allowed to die in these tests and the times recorded are those of total mortality. The following conclusions can be drawn from this work: The younger a chick is, the more vulnerable

Table 19. The relative survival of pheasants at various ages to starvation and temperature extremes.

Number of Test	Age of Pheasants (Days)	Numbers in Test Male	Numbers in Test Female	Test	Hours to total Mortality Male	Hours to total Mortality Female
1	3	95	55	"Summer shower" Heavy rain 10 minutes at 50°F. After rain, temperature to 70°F.	22.67	22.17
2	5	74	73	Same as Test 1 Rain temperature 60°F. After temperature 80°F.	17.67	17.67
3	6	87	63	Same as Test 1 Rain temperature 70°F. After temperature 90°F.	24.33	24.33
4	14	18	17	Chicks dipped in cold water until thoroughly wet; placed in room at 65°F.	25.92	31.17
5	1	11	4	Placed in chamber and remained in constant cold rain until all died.	5.92	5.00
6	1	16	19	Rain at 50°F. until all dead.	1.40	1.63
7	2	9	11	Same as Test 6	1.53	1.67
8	14	22	13	Same as Test 6	25.45	25.83
9	Mature	2	4	Temperature 0°F. Constant wind 5.8 m.p.h. No food or water	192.00	408.00
10	Mature	13	12	Outside pen. No food. Temperature varied 2° to 57°F. Snow available. Very cold and stormy.	432.00	480.00
11	Mature	2	2	Fasting; Temperature 95°F.	96.00	288.00
12	76	14	6	Fasting; Temperature 75°F.	138.00	165.00
13	21	19	16	Fasting; Temperature 60°F.	43.00	43.50

Table 19. Continued

Number of Test	Age of Pheasants (Days)	Numbers in Test Male	Numbers in Test Female	Test	Hours to total Mortality Male	Hours to total Mortality Female
14	8	9	11	Fasting; Temperature 50° to 96°F.	69.80	76.00
15	14	22	13	"	2.58	4.53
16	14	22	13	"	25.45	25.83
17	14	13	11	"	28.22	40.50
18	1	16	19	"	.67	1.00
19	1	9	13	"	134.00	134.00
20	3	20	15	"	2.05	1.70
21	3	15	19	"	2.90	2.77
22	6	4	8	"	10.00	14.00
23	6	3	9	"	14.00	14.00
24	1	12	11	"	71.67	63.67

it seems to be to wetting. Under conditions of constant rain, death seems to occur more quickly than under "shower" conditions. Even under a ten-minute shower at 50°F., with the temperature raised immediately afterward, mortality is fairly rapid in chicks up to six days of age; total mortality occurred in 24 hours. A thorough wetting results in complete mortality of chicks up to two weeks old in a maximum of 31 hours at 65°F. Whether chicks were allowed to feed during these experiments is not stated. It is assumed that they were, however, since in the fasting experiments, all chicks three days old died in a maximum of three hours, while chicks six days old all died in 14 hours, and chicks 14 days old took from one to three days for 100% mortality.

In terms of actual weather conditions, the results of Latham's investigation become very significant. The period of vulnerability would extend in most regions from the beginning of June through July, and in the case of late nesting, into the first part of August. Because the hen broods the chicks during the night, it is probably weather conditions that originate during the day that will be the most important for survival. During severe downpours of short duration, the hen is probably able to protect the chicks from wetting. Further, in a storm of short duration, followed by clearing and a period of warming and drying under sunlight, even if chicks received a wetting, there might not be excessive mortality. Under conditions of prolonged rain, or where a long period of cloudiness followed a severe downpour where chicks were wet, extensive mortality might be expected.

Prolonged rain and cloudiness may also affect chick mortality indirectly in that these conditions may prevent active feeding, or help make food unavailable. A large percentage of the diet of young pheasants is composed of insects, which are very inactive during such weather.

Surprisingly, even after a rain the temperatures near the ground are warmer than in the upper air during the day. This condition would tend to modify cold spells and protect chicks slightly. During the night, however, conditions are reversed, and a chick separated from the hen, perhaps by a storm or predators, would have somewhat less of a chance of survival because of chilling than standard weather records would indicate.

The lack of sunshine and the number of rain storms lasting over 24 hours in Rhode Island seem to be the most prominant differences in weather conditions from all the stations studied in the regions producing large pheasant populations. From the discussion above, it is possible that just these differences alone could cause extensive mortality of pheasant chicks before full feathering, and especially during the first two weeks of life.

IV. CONCLUSIONS

1. The fall diet of the ringneck pheasant in Rhode Island is composed of from 50 to 90% cultivated foods, mostly grains, and 50 to 10% wild foods. Stocked birds take the higher percentage of cultivated foods, wild birds the higher percentage of wild foods. The acreage in cultivated grains in southern Rhode Island is very small compared to the total land area and probably cannot support more than the present small pheasant population. Survey of the abundance of the wild foods commonly eaten shows that it is not likely that the uncultivated areas in southern Rhode Island can support any considerable pheasant population during the fall and winter periods.
2. Preliminary study of Gloucester and Narragansett soil samples indicates that there is a possibility that the soils of southern Rhode Island lack sufficient calcium bearing grit to maintain proper egg production and chick survival. A confirmation of this possibility by further research would indicate that such a lack might be one of the limiting factors on pheasant population in southern Rhode Island.
3. Temperature and rainfall in southern Rhode Island, as individual factors, probably do not act as limiting factors on the pheasant population.

4. The microclimate near the ground is more extreme in temperatures than the upper air. From the middle of May through the summer it is colder during the night and warmer during the day. It will modify the effect of adverse weather conditions on young chicks during the day and intensify it at night.
5. It is not probable that weather conditions cause any significant mortality in pheasant eggs.
6. Because of the number of storms of long duration and the low percentages of sunshine in Rhode Island in comparison with conditions found in Iowa, Nebraska and South Dakota, it is possible that there is considerable mortality of young pheasant chicks from chilling during the first weeks after hatching. This may have a considerable effect on population numbers in southern Rhode Island.

V. SUMMARY

Weekly observations were made at the Great Swamp Wildlife Reservation, in an attempt to assess pheasant populations, sex ratios, reproduction rates, and nesting and feeding sites. Because of the scarcity of material and the impossibility of spending more time per week in the area, this part of the project was abandoned.

The contents of 64 pheasant crops collected by the Rhode Island Division of Fish and Game were analyzed qualitatively and quantitatively for all birds, for wild birds and for birds taken from the Great Swamp. All groups of birds took the largest volume of foods in cultivated grains, the least in wild seeds. The wild pheasants, however, showed higher percentages of both occurrence and volume of wild foods, and took a larger variety of species than the stocked birds. This diet, principally because of the large quantities of bayberries found in it, is probably deficient in protein.

Six soil samples were taken from the Swamp and nearby areas, the sands and gravels extracted and examined. The principal minerals found in all samples were quartz and orthoclase feldspar. Traces of biotite, magnetite, zircon, olivine, chlorite and a black carboniferous schist were found. Of these minerals, only chlorite and the black schist contain calcium.

A qualitative survey of the dominant fall and winter vegetation was taken at the Great Swamp. The plant species found there were compared with the wild foods found in the crop analysis. There was little correlation between species forming a dominant part of the vegetation on uncultivated lands and those taken by pheasants.

Various aspects of the weather, rainfall, days of rain, percentage of sunshine, duration of storms, number of cloudy, partly cloudy and clear days and maximum and minimum daily temperatures, for the months of May, June, July and August were analyzed and compared for two stations in Iowa, Nebraska, South Dakota and Rhode Island. The only important differences found in the weather between Rhode Island and the central states were that the central states had more total days of precipitation, more sunshine and more totally clear days; Rhode Island has more cloudy days, fewer clear days, less sunshine and storms of longer duration.

A recording Bendix aerograph was placed in the Swamp and recorded temperatures, barometric pressure and relative humidity at three inches above the ground were taken. The three inch temperature readings were compared with similar data taken by Dr. Robert Wakefield. A three inch and five feet temperature series taken by Dr. Wakefield was then analyzed. It was found that during the last half of May, June, July and August, temperatures are lower near the ground during the night and higher during the day.

It was found that three environmental conditions possibly act as limiting factors on the pheasant populations in Rhode

Island: low abundance of fall and winter foods, lack of calcium in the gravels or soils, and prolonged rainy or cloudy weather during the first few weeks in the life of the pheasant chicks.

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